MANIPULATING THE OODA LOOP: THE OVERLOOKED ROLE OF INFORMATION RESOURCE MANAGEMENT IN INFORMATION WARFARE

THESIS

GREGORY M. SCHECHTMAN, B.S., M.A.S.
CAPTAIN, USAF

AFIT/GIR/LAL/96D-10

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GIR/LAL/96D-10

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Presented to the Faculty of the Graduate School of

Logistics and Acquisition Management of the

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Information Resource Management

GREGORY M. SCHECHTMAN

Captain, USAF

December 1996

Approved for public release; distribution unlimited.

Acknowledgments

I would like to begin by thanking Mr. William Gates without whom I never could have made it through my adventure at AFIT. His products colored all of my research in some way. Without them I would never have known the pleasure of sitting bleary-eyed at 0300 trying to master the intricacies of OLE while importing Excel graphs and Powerpoint slides into Word. I'm further indebted to him for having afforded me the opportunity to experience the pleasure associated with having all the computers in the lab migrate to Win95 while my documents are all in 3.1. Finally, my time here would have been incomplete without the fun of listening to cries of: "Where the heck is File Manager in this thing?" and "What *is* an Explorer, anyway?' waft through the air as I wrote my tome.

To Maj William Scott, my thesis advisor, I offer the sincerest thanks a student can give. He believed in me on the days that even I didn't. To my reader, Dr. Alan Heminger, his insights into thinking outside the box became an intricate part of this work. Capt Mike Morris is the unsung hero who helped me out. Mike jumped on the boat long after it had left port and the skipper was starting to lose the course. Mike, without you this thesis may have come together, but not nearly so well!

In closing I want to I thank my wife Sue. Her passionate belief in me was reflected in all my efforts while here at AFIT. Words simply cannot convey the admiration I have for her. Susie, you are the shmoopiest one of all!

Capt Gregory M. Schechtman

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Abstract

A ground-swell of interest in information as a weapon of warfare is growing within the U.S. armed services. Military strategists are looking at information as a tool to leverage our forces and make them irresistible in battle. Yet, there is little agreement as to what information warfare (IW) is, let alone how it is best fought. This fundamental disagreement is serving as an impediment to unified actions as the Air Force seeks its role in this arena. In particular, information resource management practitioners are questioning their role in supporting this mission. This thesis discusses limitations of existing information warfare interpretations in light of Col John R. Boyd's decision model, the Observation-Orientation-Decision-Action (OODA) Loop, and offers a synthesized model of information warfare for use in the Air Force. It then offers information resource management (IRM) as a viable decision-support mechanism in that interpretation. By analyzing the applicability of information resource management to the Air Force IW mission, this thesis proposes a better way to view information: a tool for winning the information war through making superior decisions more rapidly than our opponents. An understanding of how IRM and IW relate to one another will provide a model for achieving and maintaining dominance of this new realm of warfare.

MANIPULATING THE OODA LOOP: THE OVERLOOKED ROLE OF

INFORMATION RESOURCE MANAGEMENT IN INFORMATION WARFARE

I. Background and Statement of the Problem

General Issues

The information age has captured the minds and imaginations of military strategists throughout the Department of Defense (DoD). Their thoughts have coalesced around a concept known as information warfare (IW) as a means of waging war in which information can be seen as both a critical target and a powerful weapon. IW, as a distinct facet of war, was made possible by the dramatic price/performance improvements in computer technology of the 1980s and came of age in the Persian Gulf War.

> During the first 30 hours of the Persian Gulf War, U.S. troops were bombarded by 1.3 million electronic messages. Information poured in over radios, computers, telephones, and fax machines. The age of "information-based warfare" was born, but it was not a birth without complications. It was information overload, overwhelmed by the flood of information, troops often lacked the ability to convert data into informed decisions. (Mathews, 1995a)

Desert Storm illustrated the guiding vision for information warfare: information superiority through the availability and use of the right information, at the right place, at the right time, to all decision makers, while denying that information to the enemy (Garigue, 1996). The quest for information superiority has forged a new realm in which warfare can be conducted. The military mission in this realm is to create an information-disparity wherein the our forces hold an advantage from which they can function inside the enemy's decision-cycle (DAF, 1995c). Successful accomplishment of this mission will permit U.S. and allied forces to operate at a greatly accelerated pace. In such a fluid

environment, the adversary's decisions will be flawed because they will be implemented in situations which have changed and are based upon information which is insufficient, inaccurate, or has been modified to our advantage.

Creation of an information advantage can be generally accomplished in two ways. First, an opponent's Command-Control-Communication and Intelligence (C4I) structure can be attacked or degraded in some manner. This creates an environment in which he is relatively blind to the circumstances of the battlefield. An opponent in such straits must either react using incomplete information or seek information via other, slower and less reliable, channels. This is offensive information warfare. The second way of achieving an information advantage is by possessing greater information processing capability. This is the idea behind the electronic battlefield which emphasizes enhanced information throughput. In such a battle, troops are supplied with a plethora of computerized weapons and communications devices. Information from satellites could be beamed to field commanders in near real-time. This is information-age warfare, which has come to be called *battlespace-management*.

Defensive information warfare stands in opposition to these two approaches. Instead of seeking to produce an information advantage, its goal is to maintain the quality and quantity of our information. Defensive IW activities center around protecting against the offensive IW efforts of the adversary. Much writing has been done on the three topics of offensive IW, defensive IW, and battlespace-management. To date, however, negligible research has been conducted on how to improve decision making capabilities through superior *information* management.

Pursuing this objective (superior information management) requires viewing information warfare from a decision-making perspective. How does one make better decisions than the opponent? Can an adversary be forced into making poor ones? How can decision reaction time be decreased? All of these questions are central to IW and can be answered by possessing superior information processing abilities. The principles of information resource management are well suited to providing those answers. They have the potential to guide the evolution of information warfare and ensure successful incorporation of superior *information management* objectives within the *information dominance* mission. In IW, it is the better decision-maker who wins the battle; superior IRM can play a part in ensuring that this is the U.S..

Specific Problem Statement

The problem addressed by this research is the role of information resource management in information warfare. Despite extensive consideration of the implications of pursuing information superiority and the treatment of information as an organizational asset, no previous research addresses this question. This research uses a blended view of the two concepts, IRM and IW, in investigating the following questions:

1. What are information warfare and information resource management?
2. What is the role of decision-making in information warfare?
3. How can the application of IRM principles leverage IW by shortening the amount of time needed for decision-making?
4. Is there a tradeoff between the quality of a decision quality and the speed at which it is reached and if so, how is this reflected in IW

Scope

An analysis for improving decision-making, as depicted in a rational model of decision-making, is used as the focus for integrating IRM and IW. There are many variations of this view of the decision-making process, e.g. Herbert Simon's (1960) Intelligence-Design-Choice. This thesis focuses on John R. Boyd's Observe, Orient, Decide Act (OODA) Loop (Boyd, 1987). It is well respected among military theorists (Burton, 1993) and serves as a useful model for integrating the IRM and IW concepts.

This thesis will focus on the offensive side, particularly as it relates to decision-making. The offensive side of information warfare provides topics which are mirrored by defensive IW. One information attack can then be viewed from two angles: offensive and defensive. On the offensive side, how does one breach the defenses of the adversary and inflict the desired damage? In contrast, if one knows that the adversary will attempting to breach the defenses and will inflict harm, what are the most likely avenues the adversary will pursue and what measures can be taken to counter them? This thesis will not explore the various offensive and defensive weaponry or targeting requirements of IW outside of their inherent decision-making concerns. Instead, it will be restricted to an examination of the case for using IRM principles to guide and support IW.

Research Approach and Overview

This proposed synthesis begins with examining literature associated with information warfare, information resource management, and decision-making. Based upon a review of various current studies and articles in these fields, the researcher

extracts IRM and IW definitions and principles. These are used to create a model of information processing to describe and analyze the benefits to be derived from leveraging IW (through better and faster decision-making) with IRM principles. The research concludes with a series of case studies to illustrate the application of these principles in real-world scenarios.

This chapter presented an overview of information warfare, identified decision-making as a key component of IW, and offered information resource management as a tool to fit that need. Chapter II reviews the literature describing various definitions and principles associated with information warfare and information resource management. It concludes with a description of IW from the viewpoint of Col John Boyd's decision-making model: the OODA Loop. Chapter III presents and discusses the methodology utilized in pursuing this research. Chapter IV presents, identifies, and discusses in depth those IRM principles which are most pertinent to IW as well as providing case studies to highlight their application. Finally, Chapter V includes a discussion of the conclusions drawn from this analysis, how they address the questions stated in this chapter, and makes suggestions for how to empirically test them.

II. Literature Review

Literature pertinent to this thesis falls into two categories. The first category is information resource management (IRM). This category compares and contrasts the differing viewpoints in a prelude to developing a working definition of IRM and describes the IRM principles used in maximizing information utility. The second category is the field of information warfare. It surveys various IW definitions which emphasize different facets of this new field of study. The review concludes with the examination of a form of rational decision-making: Boyd's OODA Loop.

Information Resource Management

What is IRM?. The treatment of information as an organizational resource has it roots in the late 1970s when a significant number of firms began to treat information as a resource on a par with the more traditional ones of personnel, capital, and land (Diebold, 1979; Horton, 1979; Lewis et al; 1995). The dramatic microprocessor price/performance decreases of the 1980s spurred the use of computers in the management of corporate information (Athey and Zmud, 1988). This was evidenced by the 15% annual growth rate in information investments: the only business area to outpace economic growth (Keen, 1991; Lewis et al; 1995).

Janet Laribee, in her article "Information Resources Management in the Graduate MIS Curriculum: A Survey," describes how IRM evolved to meet the information needs of the organization:

> The field of study of information resource management has evolved to meet these needs through the more efficient use and management of information services and resources (IRM). The concept of IRM has been in existence since 1979 and is considered to be part of the discipline of Management Information Systems (MIS). Although no universal definition exists of this emerging field, it has evolved under the premise that information and its technologies are vital organizational resources and deserve to be managed as skillfully as other factors of production. (Laribee,1991:16)

This is a considerable change from seeing information as an expense. It recognizes both the *benefits* inherent in organizational information and that information needs to be *cultivated* in order to derive the most from it. IRM is then, in its simplest sense, a the set of concepts to be used in the management of information as a organizational resource (Guimaraes, 1988; McCleod, 1990; Newcomer and Caudle, 1986). However, there is some disagreement around the proper identification of the IRM construct (Guimaraes, 1988; Lewis et al, 1995).

Beyond the concepts, IRM can also be seen through a more technological lens where the focus is predominately on computerized information systems (Kercher, 1988; Smith and Medley, 1987). IRM strategies are used to integrate information system specifications (technological capabilities) with customer information requirements for data access (Cox and Forcht, 1994). In this view, IRM is a mechanism through which information technology is mapped to organizational processes and user needs (Cox and Forcht, 1994; Newcomer and Caudle; 1986; Synnott and Gruber, 1981). In spite of the ambiguity surrounding information resource management (Lewis et al, 1995), the underlying premise is that information is a valuable resource to the organization, on a par with personnel, plant, and capital and warrants treatment accordingly (Boynton et al,

1994; Desanctis and Jackson, 1994; Haney, 1989; King and Kraemer, 1988; Lewis et al, 1995; Lytle, 1988; Mahmood and Mann, 1993; Trauth, 1989). Each of these views capture different IRM qualities; together they encompass how information system (IS) professionals view the field.

IRM Historical Development. The idea of IRM within the federal government originated in a report by the Commission on Federal Paperwork in 1979 (Hernon, 1994; Johnson, 1992; Laribee, 1991; Lytle, 1986; Lewis et al, 1995; Owen, 1989; Ryan et al, 1994). "While it was primarily concerned with paperwork burden, the underlying message was that information has value and it must be managed" (Johnson, 1992). Later in the private sector, many firms facing ever increasing information system (IS) budgets also sought ways of improving the return on their IS investments. To better ensure that the organization was able to meet its current and future goals, firms began to change their approach to the application of information technologies (IT).

As early as 1980, the traditional IT structure (consisting of mainframe-based applications; piecemeal automation efforts; scattered networks; incompatible, proprietary hardware platforms; disparate software; and data files which are inaccessible to other information systems) was beginning to be seen as unable to support information growth at the rate necessary to stay viable to the organization over the long run (McCleod, 1995; State of North Carolina, 1996). While computers were originally implemented to support routine repetitive jobs (Davis and Olson, 1985) advances in capability expanded their use past task automation to focus on reporting and decision-making support (Synnott and

Gruber, 1981). Yet, even as this occurred, organizations endured systems which consistently fell short of the user's needs and expectations, were not adaptable, cost more, and took longer to implement than anticipated (Bryce, 1983). The call went out for a means of marshaling the information resources to better benefit the organization. The idea of information resource management was presented as an answer.

In the period since the findings of the original Federal Commission on Paperwork were presented, the IRM directives which have had the widest impact in the federal government are the Paperwork Reduction Act of 1980, Office of Management and Budget (OMB) Circular A-130, and the Federal Information Resource Management Regulations (FIRMR) (Johnson, 1992; McClure, 1995; Ryan et al, 1995; DAF, 1995c). These three directives outline organizational IRM responsibilities, polices, and procedures for federal agencies and are among the most important legislative documents addressing federal implementation of IRM principles (Cox and Forcht, 1994). In 1996, these were augmented by the Information Technology Management Reform Act.

The Paperwork Reduction Act of 1980. The Paperwork Reduction Act of 1980 (PRA) formalized IRM concepts and is the first major piece of legislation to recognize that information is a valuable resource (Johnson, 1992). The PRA tasks federal agencies with managing information efficiently via following information policies, principles, standards, and guidelines prescribed by the OMB. Its two-fold intent is to reduce private-sector paperwork while simultaneously reducing the federal cost of handling information (Hernon, 1994; Ryan et al, 1994). This is to be accomplished by

"ensuring that data processing and telecommunications technologies are acquired and used by the federal government in a manner which improves services delivery" (P.L. 96-511, 1980). PRA also created the Office of Information and Regulatory Affairs within the OMB and requires agencies to appoint a senior IRM official (Johnson, 1992; Ryan et al, 1995). It was reauthorized in 1986 (P.L. 99-500) then reissued in 1995 (P.L. 104-13) and continues to guide many of the federal government's information resource management efforts.

OMB Circular A-130 Management of Federal Information Resource

OMB A-130, originally issued in 1985, establishes policy for the management of federal information resources. A-130 provides guidelines for implementing specific aspects of PRA (Hernon, 1994; Ryan et al, 1994) and "a broad mandate for agencies to perform their information activities in an efficient effective and economical manner" (Johnson, 1992). Main sections of this directive are general information policy, records management, privacy, and federal automatic data processing and telecommunications. Finally, it delineates the authority of the Director of the OMB in a wide range of information-related areas.

Federal Information Resource Management Regulations. The FIRMR is a set of policies from the General Services Administration which acts as a guideline for IRM in the federal government. Its focus is to serve as the primary set of regulations governing federal agencies' management, acquisition and use of automatic data

processing (ADP) and telecommunications resources (Johnson, 1992). In the past, the computer information system focus of the FIRMR limited its applicability in many non-automated IRM functions. However, with the ever-increasing trend to automate processes and move records to digital format, this has changed dramatically. On August 8, 1996 the FIRMR was rescinded and the Information Technology Management Reform Act (ITMRA) of 1996 (Division E of Public Law 104-106) was put into effect. It adopted the basic tenets of the FIRMR and expanded its scope. President Clinton described the impact of this law.

> Executive Agencies will (a) significantly improve the management of information systems, including the acquisition of information technology. (b) refocus information technology management to support directly their strategic missions, and rethink and restructure the way they perform their functions before investing in information technology to support that work. (c) establish clear accountability for information resource management activities by creating agency Chief Information Officers (CIOs). (d) cooperate in the use of information technology to improve the productivity of Federal programs and to promote a coordinated, interoperable, secure, and shared Government-wide infrastructure; (e) establish an interagency support structure that builds on existing successful interagency efforts. (Executive Order 13011, 1996)

IRM in the Department of Defense. The Department of Defense has implemented several IRM-oriented documents beyond OMB Circular A-130, the FIRMR, and ITMRA. The DoD IRM program was created in 1983 under the authority of DoD Directive (DoDD) 7740.1 *DoD Information Resource Management Program.* Its initial goals were:

- Improve DoD mission operations and decision-making through effective and economic development and use of information .

- Integrate DoD information management activities through consistent plans programs, policies, and procedures

- Acquire and use information technology to improve mission effectiveness, productivity, and program management

- Strengthen life-cycle management of information systems

- Foster general awareness of the value of information and its associated costs (Groth et al, 1990).

Table 1 describes other significant directives which have influenced information resource management .

Table 1. DoD Directives Related to Information Resource Management

Directive	Title	Major IRM Effects
7740.2	Automated Information System (AIS) Strategic Planning	Mandates AIS strategic planning supported by architectures which address information requirements, flows, and system interfaces
8000.1	Defense Information Management Program	1) Identifies information as a corporate asset 2) Ties ISs to a DoD-wide perspective by mandating DoD-wide methods, models, data, and information technology
8120.1	Life-Cycle Management of AISs	1) Mandates use of DoD standard data definitions, IAW DoD Directive 8320.1 2) Mandates completion of functional process improvement prior to a new AIS
8320.1	DoD Data Administration	1) Defines objectives of data administration: a. Support decision-making with quality data that is accurate, timely, and available b. Structure ISs for horizontal, as well as vertical, sharing of data

Current State of Air Force IRM. The need for IRM principles has continued to grow in the US Air Force (USAF). In fact, it has adopted its own definition of information resource management: "The process of managing information resources

(information and related resources such as personnel, equipment funds and related technology) to accomplish agency missions and improve agency performance" (DAF, 1995c). Secretary of the Air Force Sheila Widnall and Air Force Chief of Staff, General Ronald Fogleman, in their opening statement in the Air Force IRM strategic plan, explain senior leadership's view of information resource management:

> To meet the challenges of the future, the Air Force must manage information as a strategic resource to enhance the Air Force mission. All Air Force members must understand the value of information resources, and use them more effectively and efficiently. Decision-makers need on-demand access to reliable and sufficient information. Finally, the Air Force must redesign and improve its business processes before applying information technology. (DAF, 1995c)

Thus, it appears that IRM will be an integral part of decision making in the military for quite a while. The trend is in part due to the aftershocks of Dessert Storm, which many are calling the first true information war (Campen, 1992). It was during this conflict that the military realized the significant impact using an information approach could have on the outcome of a war. Desert Storm was the *100-hour* War in part because of the information-related operations conducted within it.

IRM Principles. A review of the literature reveals that there is a lack of consensus as to what constitutes information resource management (Laribee, 1992; Lewis et al, 1995; Miller, 1988, Owen, 1989). Evidence of the ambiguity surrounding it is provided by Lewis et al (1995). The researchers undertook a study to clarify the IRM construct. They reviewed academic and professional literature together with MIS books spanning the 1975-1995 time period. "Searches were conducted for the terms information resource

(s) management and IRM. The rationale for this search (is) authors who label their publications with this term are contributing to the explication of the IRM construct," (Lewis et al, 1995:204). They derived their definition of IRM from the results of this survey.

> IRM is a comprehensive approach to planning , organizing, budgeting, directing, monitoring and controlling the people, funding, technologies and activities associated with acquiring, storing, processing and distributing data to meet a business need for the benefit of the entire enterprise. (Lewis et al, 1995:204)

Their research revealed forty-four different IRM activities dominating the literature (See Table 2).

Table 2. IRM Activities From a Content Analysis of the Literature

1. Integrated computer based information systems
2. Integrated communications
3. Integrated office automation
4. Data integration across applications
5. Application systems integration
6. Local IT facilities(microcomputers, workstations, minicomputers, LANs and servers)
7. IT architecture: computers and communications
8. Assess potential of new technology
9. CIO establishes organization-wide IS/IT policies
10. CIO involved in organization-wide strategic planning
11. CIO responsible for central and distributed IS/IT support
12. CIO authorizes corporate-wide IT acquisitions
13. Program for quality assurance of information systems
14. Data administration function
15. Data Architecture
16. Data ownership policies
17. Data dictionary
18. Data shared between users
19. Data security
20. Access control security
21. Security awareness program
22. Corporate-wide IS/IT plan
23. IS/IT plan encompasses MIS and EUC
24. IS/IT plan reflects business strategies
25. Support for end user computing
26. Training programs for end users
27. Information center support
28. Control of technology resides with users
29. Users involved n planning
30. Support provided for user management decision making (DSS/EIS)
31. Management and support of information resources is the responsibility of users
32. Distributed technology standards
33. Adherence to distributed technology standards
34. Cooperative processing and client/server facilities
35. Telecommunications between and within distributed and central facilities
36. Formal guidelines for systems analysis, design, development and implementation
37. Automated development tools
38. Business/enterprise model
39. Documentation of corporate data flow
40. Data/information inventory
41. Inventory of IT facilities
42. Policy/review/advice oversight committee
43. User participation oversight committee
44. Executive-level participation

(Lewis et al, 1995)

From these activities they described eight dimensions of IRM:

Chief Information Officer: A chief information officer who is responsible for corporate-wide information-technology policy, planning, management, and acquisitions

Planning: An inclusive information systems/technology planning process that reflects business goals, encompasses both central and distributed technologies, involves end-users, and features a mechanism for assess the potential of new technologies

Security: A comprehensive security program that includes access control and data security, a security awareness effort, and a disaster recovery plan

Technology Integration: A comprehensive and integrated approach to information technologies, including computing, telecommunications, and office automation

Advisory Committee: Advisory committees that deal with systems and technology issues and include both senior management and users

Enterprise Model: An enterprise model approach featuring documented business processes, a development methodology, inventories of facilities and information, corporate-wide technology standards, and the use of automated development tools

Information Integration: Integrated data and applications systems, with data shared between users

Data Administration: A data administration function headed by a database administrator and based on a corporate data architecture, which utilizes a data dictionary and features policies on data ownership. (Lewis et al, 1995)

The IRM dimensions serve as a foundation from which a set of core principles can be culled. This is accomplished through expanding Lewis et al's descriptive dimensions to cover the broader responsibilities that IRM is tasked with providing, and then re-grouping the activities under these new principles. The principles would thus serve as a middle ground between the numerous independent activities listed in their study and the descriptive functions cited by them. Figure 1 depicts the core principles of information resources management.

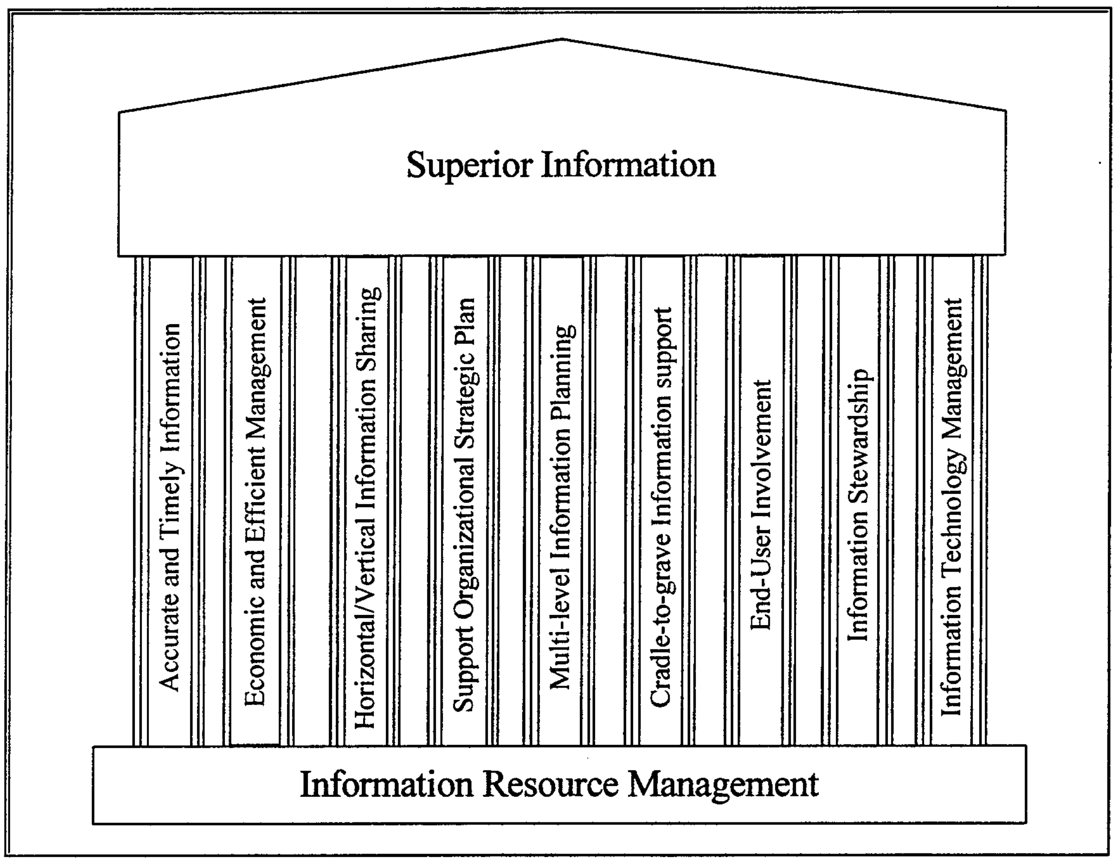


Figure 1. Core IRM Principles

Table 3 matches IRM activities with the principles which encompass them; . The section following it describes, in detail, those principles which are central to IRM efforts.

Table 3. IRM Activity/Principle Cross-Table

IRM Activities	IRM Core Principles	Accurate and Timely Information	Economic and Efficient Management	Horizontal/Vertical Information Sharing	Support Organizational Strategic Plan	Multi-level Information Planning	Cradle-to-Grave Information Support	End-User Involvement	Information Stewardship	Information Technology Management
Integrated computer based information systems			X	X						X
Integrated communications			X	X						X
Integrated office automation			X	X						X
Data integration across applications			X	X						X
Application systems integration			X	X						X
Local IT facilities			X	X						X
IT architecture: computers and communications			X	X						X
Assess potential of new technology			X							X
CIO establishes organization-wide IS/IT policies					X				X	X
CIO involved in organization-wide strategic planning					X				X	
CIO responsible for central and distributed IS/IT support					X				X	X
CIO authorizes corporate-wide IT acquisitions					X				X	X
Program for quality assurance of information systems									X	
Data administration function							X		X	
Data Architecture							X			
Data ownership policies							X		X	
Data dictionary							X			
Data shared between users		X		X			X	X	X	
Data security							X		X	
Access control security							X			
Security awareness program							X	X		
Corporate-wide IS/IT plan			X		X	X	X			X
IS/IT plan encompasses MIS and EUC						X				X
IS/IT plan reflects business strategies					X	X				
Support for end user computing		X						X		
Training programs for end users								X		
Information center support							X	X		
Control of technology resides with users								X		
Users involved n planning						X		X		
Support provided for user management decision making		X						X		
information resources is the responsibility of users							X			X
Distributed technology standards										X
Adherence to distributed technology standards										X
Cooperative processing and client/server facilities										X
Telecomm between distributed and central facilities										X
Formal guidelines for systems analysis		X	X			X				
Automated development tools										
Business/enterprise model						X				
Documentation of corporate data flow							X			X
Data/information inventory						X	X			
Inventory of IT facilities			X							
Policy/review/advice oversight committee					X					
User participation oversight committee						X		X		
Executive-level participation					X					

- **Timely and Accurate Information:** ***Support decision-makers via readily available, accurate, and timely information***

Information resource management's value lies in support of the decision-making process (Lytle, 1988; DAF, 1995c) Obviously, the decision-maker must be able to retrieve stored data: unavailable information is useless when decisions must be made. Further, the retrieval must be able to be accomplished within a reasonable time period. Finally, and most importantly, the information must accurately reflect the reality of the organization's situation. The use of enterprise-wide data modeling can further assure that common data models are employed across the organization systems (Martin, 1989a). Lewis et al's (1995) study cited 4 activities which fit this particular principle:

Data shared between users
IS/IT plan reflects business strategies
Support provided for user management decision making (DSS/EIS)
Formal guidelines for systems analysis, design, development and implementation

- **Economic and Efficient Management:** ***Acquire and manage information resources in an economic and effective manner***

A major IRM task is ensuring organizations have a means for maintaining adequate information resources (USC: P.L. 96-511, 1980). This is no small feat. An estimated 50% of new capital investments by major US corporations are information-system related (Laribee, 1991; Laudan and Turner 1989). In the case of information resources, this requirement of adequate resources translates into both maintaining existing information systems and acquiring new ones (Synnott and Gruber, 1981). IRM is concerned with the efficacy of people, hardware, software, and procedures connected to information management (McCleod, 1995). When change is needed it is the IRM task to

assure the acquisition/implementation of a system designed to fit the overarching needs of the enterprise in addition to the needs of the individual (Groth et al, 1990; Martin, 1989a; Miller, 1988). Lewis et al's (1995) study cited 11 activities which fit this particular principle:

Integrated computer based information systems
Integrated communications
Integrated office automation
Data integration across applications
Application systems integration
Local IT facilities(microcomputers, workstations, minicomputers, LANs and servers)
IT architecture: computers and communications
Assess potential of new technology
Corporate-wide IS/IT plan
Formal guidelines for systems analysis, design, development and implementation
Inventory of IT facilities

- **Horizontal/Vertical Information Sharing:** ***Cultivate horizontal as well as vertical information sharing***

Information systems must be designed to support both vertical and horizontal information exchange (Bryce, 1983; Guimaraes, 1988) . Increasingly, there exists a need to share information horizontally; often across functional boundaries (Miller, 1988). Older, stand-alone systems were not designed to support this ability. Maximization of information utility requires that access be afforded wherever the organization deems it necessary (Owen, 1989). As such, the management of information should not be constrained by a vertical-orientation paradigm. Lewis et al's (1995) study cited 8 activities (1-7 and 18) which fit this particular principle:

Integrated computer based information systems
Integrated communications
Integrated office automation
Data integration across applications
Application systems integration

Local IT facilities(microcomputers, workstations, minicomputers, LANs and servers)
IT architecture: computers and communications
Data shared between users

- **Support Organizational Strategic Plan:** ***Link strategic information planning to support of organizational objectives***

Information resources should be employed in a manner consistent with an organization's strategic plan (Hernon, 1994; Owen, 1989). In much the same way that capital is utilized to further production, information must be structured so that it supports the enterprise's mission (Guimaraes, 1988; Haney, 1989; Owen, 1989; Smith and Medley, 1987). Such structuring cannot take place without a definite plan describing anticipated future information requirements together with the goals and objectives necessary to meet those needs (Groth et al , 1990). The explicit statement of goals and objectives contained in the information strategic plan help clarify development efforts and ensure the direction planned for the IS is congruent with the overall direction of the organization (Johnson, 1992). Lewis et al's (1995) study cited 9 activities which fit this particular principle:

CIO establishes organization-wide IS/IT policies
CIO involved in organization-wide strategic planning
CIO responsible for central and distributed IS/IT support
CIO authorizes corporate-wide IT acquisitions
Corporate-wide IS/IT plan
IS/IT plan reflects business strategies
Policy/review/advice oversight committee
User participation oversight committee
Executive-level participation

- **Multi-level Information Planning:** ***Implement information planning at all management levels***

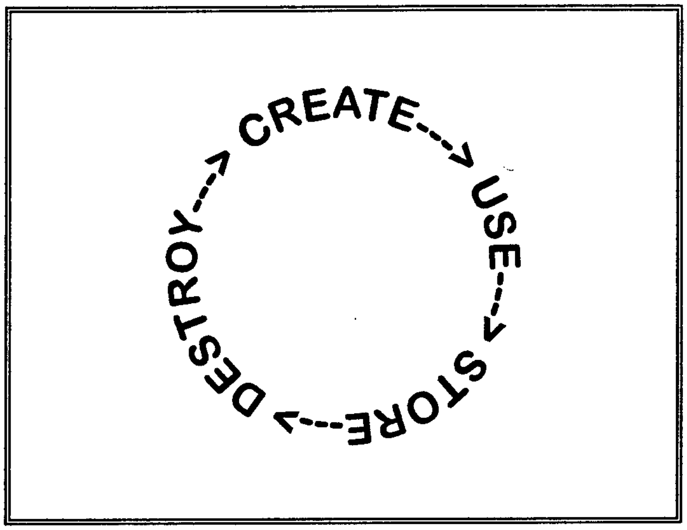
Increasingly, organizations are turning to IRM as a means to shape information assets coherently (Kerr, 1991). However, information planning should not be the

exclusive domain of any particular management level (Horton, 1979). To some degree, information management tasks at all levels tend to follow Mintzberg's management roles: planning, organizing, and controlling information resources (Boynton and Zmud, 1987). Operational, tactical, and strategic management each have unique information needs. Pursuit of these functions and information planning should include support for all of them. Additionally, the levels do not operate in a vacuum. An enterprise-wide orientation demands accounting for how the effects of planned changes in one level will affect systems supporting others (Martin, 1989a). Lewis et al's (1995) study cited 8 which fit this particular principle:

Corporate-wide IS/IT plan
IS/IT plan encompasses MIS and EUC
IS/IT plan reflects business strategies
Users involved n planning
Formal guidelines for systems analysis, design, development and implementation
Business/enterprise model
Data/information inventory
User participation oversight committee

- **Cradle-to-grave Information Support:** ***Provide cradle-to-grave information management***

Information management requires recognition of the flow of information through an organization (See Figure 2).



(DAF, 1995c)

Figure 2. The Information Life Cycle

Organizations are constantly acquiring information from their environment and/or producing it internally (*create*). It is then employed somehow in the accomplishment of organizational goal and objectives (*use*). At this point, it is stored (possibly in some semi-permanent medium) for retrieval and use at some later date (*store*). Finally, when, for whatever reason, the organization has no use for it, the information is discarded (*destroy*). Management requirements will differ by stage of the information life-cycle. IRM is concerned with cultivation of the information resource so that it can contribute to achievement of organization goals (DAF, 1995c). Adopting this concept mandates tailoring IS development efforts to fit the needs of information in each stage of the life cycle. Lewis et al's (1995) study cited 14 activitieswhich support this particular principle:

Data administration function
Data Architecture
Data ownership policies

Data dictionary
Data shared between users
Data security
Access control security
Security awareness program
Corporate-wide IS/IT plan
IS/IT plan encompasses MIS and EUC
Information center support
Management and support of information resources is the responsibility of users
Documentation of corporate data flow
Data/information inventory

- **End-User Involvement:** ***Involve end-users in all stages of the information life-cycle***

Traditionally, surveying the user for their information requirements has been the primary tool used to uncover their perceived needs. The underlying assumption of this approach is that the user can forecast what they will need (Goodhue, Quillard, and Rockart, 1988). IS professionals posses the skills necessary to construct an information system. Yet, it is the user, tasked with accomplishing a job, who has the best capacity to describe the necessary IS functionality. A flaw of system development in the past has been a reluctance to let the desires of the user drive the system's characteristics. This can be overcome by ensuring active user participation in information management (Hoffman et al, 1988). Lewis et al's (1995) study cited 9 activities which fit this particular principle:

Data shared between users
Security awareness program
Support for end user computing
Training programs for end users
Information center support
Control of technology resides with users
Users involved n planning
Support provided for user management decision making (DSS/EIS)
User participation oversight committee

- **Information Stewardship:** ***Emphasize information stewardship not information ownership***

Information is an asset of the entire organization. No one individual or department can lay claim to owning any of the information gathered, processed, or stored by them (Horton, 1979; State of North Carolina, 1996). Instead, members are entrusted with guardianship of a piece of the organization's information (EPA, 1996). It is incumbent upon them to manage it in a manner that benefits the overall enterprise. This involves cultivating information and ensuring its widest dissemination with due regard to security and privacy (Hoffman et al, 1988; Kerr, 1991). Lewis et al's (1995) study cited 9 activities which fit this particular principle:

CIO establishes organization-wide IS/IT policies
CIO involved in organization-wide strategic planning
CIO responsible for central and distributed IS/IT support
CIO authorizes corporate-wide IT acquisitions
Program for quality assurance of information systems
Data administration function
Data ownership policies
Data shared between users
Data security

- ***Exploit information technology to benefit the organization***

"Modern (information) infrastructure must store information for rapid retrieval, presentation, and projection any place in the world," (Ryan et al, 1994:307). IRM is tasked with ensuring that the organization is structured to get maximum benefit from its current information hardware and software. Furthermore, the organization should be positioned such that technological innovations can be identified and capitalized on to improve information processing in a cost effective manner (Groth et al 1990). In fact,

Niederman et al (1991) conducted a study in which senior executives identified IT infrastructure-related topics as 3 of the top 10 IS issues. Most of Lewis et al's (1995) study would fit here. However they cited 19 activities which are particularly well suited to inclusion in an IT principle:

Integrated computer based information systems
Integrated communications
Integrated office automation
Data integration across applications
Application systems integration
Local IT facilities(microcomputers, workstations, minicomputers, LANs and servers)
IT architecture: computers and communications
Assess potential of new technology
CIO establishes organization-wide IS/IT policies
CIO responsible for central and distributed IS/IT support
CIO authorizes corporate-wide IT acquisitions
Corporate-wide IS/IT plan
IS/IT plan encompasses MIS and EUC
Management and support of information resources is the responsibility of users
Distributed technology standards
Adherence to distributed technology standards
Cooperative processing and client/server facilities
Telecommunications between and within distributed and central facilities
Documentation of corporate data flow

The above IRM principles are especially important in the public sector, where according to the General Services Administration (1993), "the federal government is the nation's largest single producer, consumer, and disseminator of information". Recognizing this, the federal government has turned to IRM (and the streamlining it can bring about) as a means of enabling spending cuts and business process reengineering in its agencies (Cox and Forcht, 1994). This trend is seen in the myriad laws in existence concerning information management. "In fact, Congress passed more than 300 public laws alone between 1977 and 1990 related to information policy and technology" (Chartrand, 1991; Ryan et al, 1994).

Information Warfare

> Attaining one hundred victories in one hundred battles is not the pinnacle of excellence. Subjugating the enemy's army without fighting is the true pinnacle of excellence
>
> Sun Tzu, The Art of War

> Dominating the information spectrum is as critical to conflict now as occupying the land or controlling the air has been in the past
>
> General Ronald Fogleman, USAF Chief of Staff

Due to the relative infancy of IW as a field of study, there is no widespread agreement as to how to define information warfare. To overcome this obstacle, this section will briefly discuss a number of information warfare attributes and review some of the important IW theories. It also examines rational decision-making models, particularly, Colonel John Boyd's OODA Loop, as a viable tool for exploring how decisions are made and how this supports IW.

Information Warfare Attributes. A preliminary task undertaken in qualitative research is to build a conceptual framework from which to begin (Miles and Huberman, 1984) This establishes a common understanding of the terms forming the problem domain and provides a link between the reader and the researcher. This has also proven true in an exploration of information warfare. In reviewing the literature, alternative terms such as information-based war and knowledge-based war, cyberwar and netwar, and command and control warfare are often used interchangeably with information

warfare (Buchan, 1996). Given the lack of a universally agreed upon view, it may be useful to approach the issue by considering the defining attributes of information warfare theories. The primary attributes are: 1) information vs. data, 2) information systems, and 3) decision-makers.

A basic IW attribute is that information is more than an amalgamation of sensory inputs. This collection of inputs, lacking any significant interpretation, would merely be data. It is not until the data is manipulated and meaning ascribed to it that it becomes information (McFadden and Hoffer, 1991; Rob and Coronel, 1993). This information is both the tool (instrument used in an attack) and the target (object against which an attack is initiated) in IW (Cochrane, 1996; Hazzlet, 1996; Schwartau, 1994). According to Colonel John Boyd's theory, expounded in his lecture *A Discourse on Winning and Losing,* information is the target because the goal in *any* conflict is to constrict one's decision making cycle relative to the enemy by having better information flows than him (1987).

Information systems, are the second facet of dimension of IW. Colonel Richard Szafranski expands the IS definition to include information systems as "a comprehensive set of knowledge, beliefs, and the decision-making processes and systems of the adversary" (Szafranski, 1995:10). Roger Thrasher, in his 1996 master's thesis, *Information Warfare: Implications for Forging the Tools*, examined this aspect of information warfare through a delphi panel of experts. Many of the ideas emerging from that panel dealt with the placement of information system attacks within the sphere of

IW. Two comments illustrate the importance attached to information systems as a facet of information warfare:

> True information warfare is the use of information and information systems as weapons against targeted information and information systems. (Schwartau, 1996)

and

> I limit IW to information in electronic form and the hardware and software by which it is created, modified, stored, processed and moved about. (Campen, 1996)

The third aspect of information warfare is the decision-maker. Since this is the adversary's control point, it is here that the potential for leverage is greatest. Boyd feels that the objective in any military information campaign is "to break the spirit and will of the enemy commander by creating surprising and dangerous operational and strategic situations" (Fadok, 1995:14). Professor George Stein (1995), of Air University similarly sums up this idea in his 1995 essay *Information Warfare:*

> Information warfare is fundamentally about influencing human beings and the decisions they make. The target of information warfare, then is the human mind, especially those minds that make the key decisions of war or peace and, from the military perspective, those minds that make the key decisions on if, when, and how to employ the assets and capabilities embedded in their strategic *(military)*structure. (Stein, 1995)

These three attributes: information, information systems, and decision-makers are the basic IW components. Most IW definitions build on them.

<u>Current Information Warfare Definitions</u>. Since there is no readily agreed upon definition for information warfare (Buchan, 1996) this section will review some of the major ones currently in use. One of the most often cited authors in the IW field is Winn

Schwartau, author of *Information Warfare: Chaos on the Electronic Superhighway*. His definition of information warfare is "an electronic conflict in which information is a strategic asset worthy of conquest or destruction' (Schwartau, 1994:13). Similar to Schwartau's view is that of Canadian Strategic Information Technology Specialist Robert Garigue. He defines information warfare as "all efforts to control, exploit, or deny an adversary's capability to collect, process, store, display, and distribute information, while at the same time preventing the enemy from doing the same" (Garigue, 1996). The ambiguity of IW is illustrated in the following cross-section of information warfare definitions:

- An electronic conflict in which information is a strategic asset worthy of conquest or destruction. (Schwartau, 1994)
- Any action to deny, exploit corrupt, or destroy the enemy's information and its functions; protection ourselves against those actions; and exploit our own military information functions. (DAF, 1995c)
- Any activity motivated by the need to alter the information streams going to the other side and protect one's own. (Libicki, 1996)
- A conflict between two parties where information technology is the primary means of obtaining a defensive or offensive advantage. (King, 1996)
- Information warfare, in its essence, is about idea and epistemology...it is about the way humans think and, more importantly, the way humans make decisions. (Stein, 1996)
- Actions taken to create an information gap in which we possess a superior understanding of a potential adversary's political, economic, military, and social/cultural strengths, vulnerabilities, and interdependencies that our adversary possesses on friendly sources of national power. (Hutcherson, 1994:53)
- All efforts to control, exploit, or deny an adversary's capability to collect, process, store, display, and distribute information while at the same time preventing the enemy from doing the same. (Garigue, 1996)

The U.S. military has evolved its own description of what information warfare means. The Department of Defense is moving toward establishing an over-arching definition in which the subordinate services can find a supporting niche. The DoD definition calls information warfare:

> Actions taken to achieve information superiority in support of national military strategy by affecting adversary information and information systems while leveraging and defending our information and systems. (Haeni, 1995)

The emphasis of this particular definition is that IW must support our national military strategy through creating actions at a strategic level. This is a deviation from others, such as Schwartau, who also include IW actions directed at individuals and organizations outside of nation-state conflict (Magsig, 1995).

Cornerstones of Information Warfare is the 1995 Air Force document which describes the Air Force view of IW. It describes information warfare as:

> Any action to deny, exploit, corrupt, or destroy the enemy's information and its function; protection ourselves against those action; and exploit our own information functions. (DAF, 1995a)

The goal of information warfare is information dominance or "a degree of superiority in information functions that permits friendly forces to operate at a give time and place without prohibitive interference by the opposing force" (DAF, 1995b). Under such a broad tasking, the term information functions describes a whole gamut of operations.

The Quest for Information Superiority

Based on this review, it appears some aspects are common to most information warfare definitions: information, information systems, and decision-makers. However, each definition tends to focus on either the information itself or the information system. Few focus purely on the decision-maker and even less adopt a holistic approach. Such an approach to information warfare, with a balancing of all three components, would be the better method (Buchan, 1996) This would minimize the emphasis on what should or should not be included as part of information warfare. The goal in any conflict is to win and information warfare is not different. Within ethical limits, it does not matter whether IW is targeted against the information, the system or the decision-maker. Merely that the results of such actions convey an information advantage. The value inherent in any information-related tactic is its improvement of decision-making relative to the adversary. Colonel John R. Boyd's Asymmetric Fast Transient theory of conflict captures this idea (Boyd, 1987). A significant subset of this theory is the OODA Loop model.

Boyd's OODA Loop. While there are many models of decision making, not all adopt a rationalistic approach. The rational model, in its strictest sense, states that people pragmatically choose among different alternatives by moving through a series of steps based upon their knowledge of the situation and the desirability of the alternative outcomes (Simon, 1960). Several variations on the rational model exists. The one chosen for use in this research is Boyd's OODA Loop.

The OODA Loop is part of Col John Boyd's Asymmetric Fast Transient theory of conflict. This model is widely recognized in the profession of arms, where some consider him to be one of the premier military theorists in the United States (Wyly, 1993). Col James G. Burton, USAF (Ret.) shows the degree to which Boyd as become a respected conflict theorist.

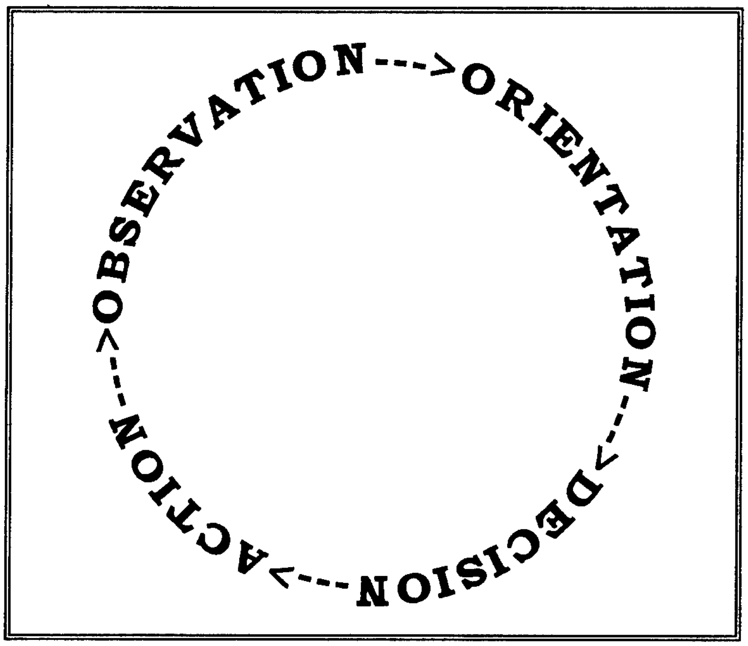
> Between 1987 and 1991, the Marine Corp's Amphibious Warfare School at Quantico, Virginia distributed one thousand copies (of Boyd's work) and incorporated his theories into its own doctrine. During countless hours in private session Boyd explained his theories to (future Secretary of Defense) Richard Cheney... two copies of (his work) were even in the White House at the start of the Gulf War. His treatise, "A Discourse on Winning and Losing" will go down in history as the twentieth century's most original thinking in the military arts. No one, not even Karl Von Clausewitz, Henri de Jomini, Sun Tzu, or any of the past masters of military theory, shed as much light on the mental and moral aspects of conflict as Boyd. (Burton, 1993:10)

Table 4 shows a cross-section of authors citing or using his concept.

Table 4. Authors Citing John Boyd's Concepts

Author	Title	Association
Jeffrey Cooper	Dominant battlespace awareness and future warfare	NDU
Martin Libicki	What is information warfare?	NDU
Anonymous	Air Force Manual 1-1	USAF
Col James W. McLendon	Information warfare: impacts and concerns	USAF
Daniel E. Magsig	Information warfare in the information age	USAF
Anonymous	Cornerstones of information warfare	USAF
Col Philip S. Meilinger	Ten propositions regarding airpower	USAF
Col Richard Szafranski	A theory of information warfare: preparing for 2020	USAF
George Stein	Information warfare	Air War College
Scott A. Bethel, et al	[2025] Information Operations: A New Warfighting Capability	Air University
F. J. West, Jr.	War in the pits: marine-futures traders wargame	President GAMA Corp

The model's fundamental premise is that decision-making is the result of rational behavior (Boyd, 1987; Fadok 1995). As such, the process can be depicted as a cycle of the four stages: observation, orientation, decision, and action (OODA). Boyd's model is illustrated below (See Figure 3).



(Boyd, 1987)

Figure 3. The OODA Loop

Boyd contends that decision-making follows a rational series of steps. Initially, people scan their surroundings and gather data from it (observation). Based upon this intelligence, they form a mental image of the circumstances within which their decision must be carried out (orientation). The decision is then made (decision) and then

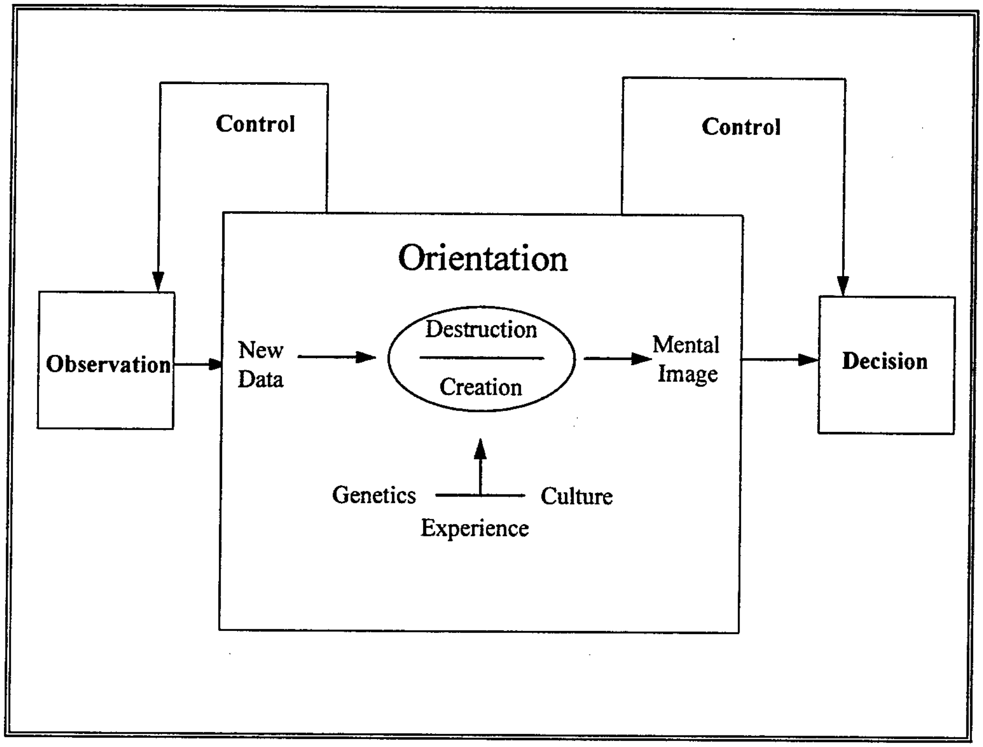
implemented (action). The goal of conflict in the Asymmetric Fast Transient theory is to navigate through the OODA loop more rapidly than the adversary (effectively constricting the loop) through reducing one's fog and friction while increasing that of the adversary.

Fog and friction are two concepts from Carl Von Clausewitz's *On War*. Clausewitz stated, that "countless minor incidents--the kind you can never really foresee--combine to lower the general level of performance, so that one always falls far short of the intended goal," (Clausewitz, 1984:119). This is the friction of war. Generally, it can be categorized as resulting from an adverse *physical* environment (darkness; poor weather; terrain; physical exertion; degraded or limited command and control; and chance) or from *psychological factors* (stress produced by the interaction of combatants and the environment of war) (Clausewitz, 1984). Fog is the concept of uncertainty in war (Clausewitz, 1984). Among the countless sources of uncertainty are incomplete and/or contradictory information, chance actions of the enemy, deviations in weapon system efficacy, and the enemy's nebulous capabilities and intentions (DAF, 1992).

Fog and friction can be manipulated to alter the tempo at which opposing militaries can operate. In conflict, both sides are attempting to accomplish this task simultaneously. The successful one will have a smaller OODA loop which enables him to seize the initiative, operate at a quicker tempo, and force the opponent into a defensive stance (Crawford, 1995; Fadok 1995). Battle, according to Boyd, can be viewed as a series of time-competitive observation-orientation-decision-action cycles (Smith, 1989).

Observation. The first phase of the decision-making process is observation. Observation refers to the necessity of becoming aware, especially through careful and directed attention (DAF, 1992). The decision-maker must observe what is taking place and determine the circumstances under which he or she must function. It is here that the data of situation analysis is collected. Orientation is the processing of this data into usable information.

Orientation. After data on the situation is collected, it must be mentally synthesized into information. Orientation is about making sense out of the observations. It is where an initial assessment begins and a mental picture of the world is created. Figure 4 graphically illustrates this process. Initially, new data is introduced from the observations of the environment.. It is then merged into the existing mental framework and a process of destruction and creation occurs. When it is incorporated, the current mental image is destroyed and a new one emerges which embodies the new data. The destruction/creation process varies by person because it incorporates unique personal characteristics such as genetics, culture, and experience. The mental image which forms during orientation serves as the foundation upon which the decision will occur. The orientation process also interacts with the observation and decision phases in that changes in the mental image cause additional data collection forays (observe) and /or change the way decisions are made (decide).



(Fadok, 1995)

Figure 4. Orientation in the OODA Loop

The speed at which orientation takes place is important. Survival in the complex world of conflict depends on quickly and accurately developing mental images to help comprehend the vast array of threatening events (Fadok, 1995:16). Orientation is the most important part of Boyd's cycle and is influenced by many factors such as by genetic heritage, beliefs, and cultural traditions (Szafranski, 1995).

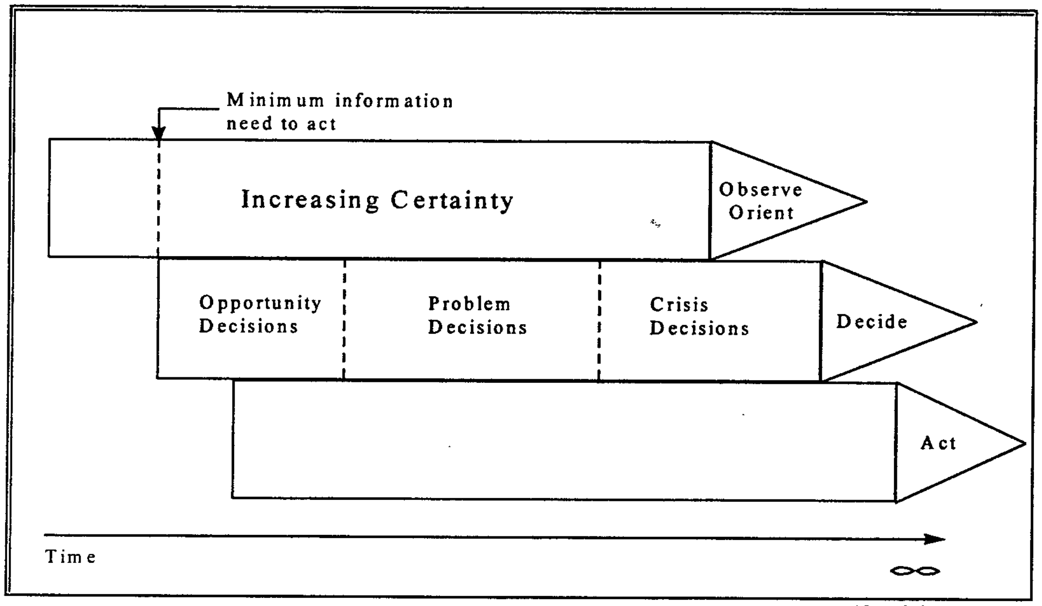
> The orientation of American leaders is different than the orientation of, say, Japanese or Chinese leaders. The orientation of capitalists and their leaders is different than the orientation of socialists and their leaders. Unlike knowledge systems, belief systems are highly individualized. Why? They include the stuff of the unconscious and subconscious, powerful elements of which others and even the bearer may be unaware. (Szafranski, 1995)

Take together, observation and orientation form the first half of the OODA loop. They comprise that part of the decision process where data is gathered, synthesized, and interpreted.

Smith (1989) identified five impediments or mental blocks influencing efficient accomplishment of these tasks: 1) People require different levels of detail to perceive an event occurring; 2) People will require 3-5 occurrences of an event before they recognize it (three-to-five rule); 3) The existence of preconceived notions where information which does not conform to one's view of reality is ignored or given less merit; 4) Good news is reported quickly while bad news will be withheld as long as its holder believes he can change the outcome; and 5) Communication problems, i.e. proper encoding and decoding of ideas such that the message received is identical to the one intended to be passed. The impact of all of these factors is to slow down the observation-orientation portion of the OODA Loop. Once these have been overcome, and orientation is accomplished, a decision is made.

Decision. Coming to a decision is the third step in the OODA loop. Here, the decision-maker weighs the information acquired during the first half of the cycle. Based on this, he considers the possible options and chooses which he will pursue. The amount of information necessary to come to a decision varies. However, every decision requires a certain minimum amount of information before it can be reached (Smith, 1989). Time spent in acquiring information beyond this point is time wasted. Figure 5 shows the effect of this phenomenon. Once the minimum level of information has been

obtained an opportunity exists. However, as increasingly greater amounts of time are dedicated to information gathering, opportunity is lost and a problem situation evolves. If the decision is put off long enough, the problem will grow to crisis proportion (Smith, 1989). To constrict the OODA loop, decisions need to be made and then acted upon as soon as the minimum information is acquired.



(Smith, 1989)

Figure 5. Certainty/Time Interaction

Action. The last step in the cycle is action. It is here that the previous efforts, which culminated in a decision, are put into effect. Observation of the action's results occurs, and the cycle is repeated again and again. The length of time needed to cycle from observation to action is captured graphically in the OODA loops diameter. Using a shorter amount of time to move from observation through to action is depicted as a smaller cycle; a longer time as a larger one (See Figure 6).

Boyd's contention is that the decision-makers' cognitive processes are the key to prevailing in a conflict. Information warfare then, must be predominantly concerned with denying the enemy the time needed to adjust/adapt to wartime situations. This is done by creating and perpetuating a highly fluid and menacing state of affairs for the enemy (wartime friction and fog) and by disrupting the enemy's ability to adapt to such an environment (Fadok, 1995). The telescoping of time, arriving at decisions more rapidly than the enemy can cope with, is the decisive element in war due to the enormous psychological strain it places on an the adversary (Meilinger, 1994).

One of the most important suppositions is that the *best* measure of efficiency is how one's loop measures relative to the opponent. Much like the DoD and USAF IW definitions, Boyd holds offensive and defensive functions in equal importance. The goal in conflict becomes equally to minimize one's own decision cycle and maximize that of the enemy.

> An engagement between two opposing sides can be seen as a competition to possess the smallest OODA loop. The side with the smallest OODA loop operates at a much higher tempo, forcing the opposing side to react to its moves. Through a successful campaign of subversion, deception and psychological operations, friendly forces can increase the size of an opponent's OODA loop, while reducing the size of their own. (Crawford, 1995)

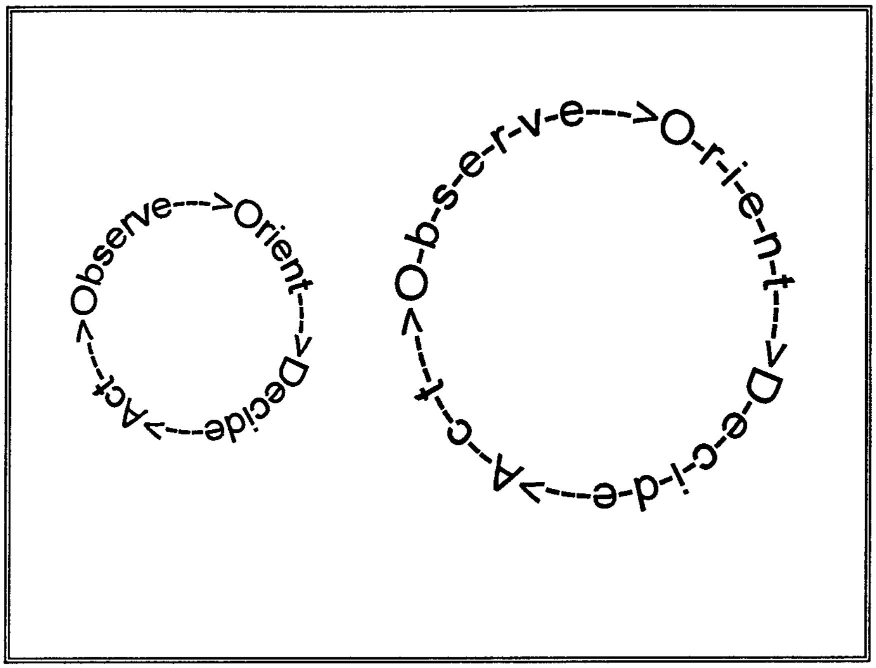


Figure 6. Comparative OODA Loops

The loop on the left side of figure 6 is constricted as compared to the other. This size difference could be the result of any number of factors such as using less time to collect, analyze and disseminate observations; superior orientation skills, or the decisiveness of the commander. In the Asymmetric Fast Transient theory of conflict, the goal is to move faster than the opponent can react two, e.g. constrict your loop. Information warfare is then not necessarily limited to optimizing your decision making process, but also, concentrating efforts such that an enemy must satisfice for a poorer quality decision, due to the lack of information about the problem and consequences of potential alternatives (Thrasher, 1996).

Summary

Information warfare is the fight to make better decisions at a faster pace than the adversary. Such predominance can best be brought about through an approach which takes into account all levels of IW: information, information systems, and decision-makers. Col John R. Boyd's OODA Loop can be used to model such an approach. It is the goal of IRM to manage corporate information such that the organization derives maximum utility from it. As such it fills a niche in information warfare which satisfies the requirement for superior information management. The following chapter discusses the methodology employed in the investigation of the role of IRM in IW.

III. Methodology

This chapter explains the data accumulation and analysis methods followed to answer the question, what is the role of information resource management in information warfare? Although the Air Force has recently defined its view of information warfare, it does not specify what, if any, roles IRM plays in it. Further, although several studies describe what IW entails, none view it through an IRM perspective. This study utilizes qualitative techniques to examine previous information warfare and information resource management research and propose a new model for Air Force information warfare efforts. The model provides a way to employ IRM principles to improve IW through impacting the OODA Loop

Historical Research

In order to provide a clearer direction for the DoD and Air Force, it is necessary to identify possible advantages that can be derived from applying an IRM focus to the IW realm. A review of previous approaches to IW provides a foundation for information warfare doctrine. From the historical base one can measure the extent to which the literature investigates IW as the quest for superior decision making, as opposed to focusing on either the effects of striking a blow to the information systems of an adversary or the vulnerability of U.S. information systems. It is only when that base has been built that new IW doctrine can be offered through original research.

Research Design

The Miles and Huberman (1984) interactive model of qualitative analysis (see figure 7) provides the format for the research effort used in this thesis. The first of four steps in this model is data collection (Miles and Huberman, 1984). As was stated in the chapter 2 literature review, for the purposes of this research, data collection begins with a review of past and current IW definitions, exploring the tenets of information resource management, and examining rational decision-making. After data collection, data reduction occurs where the data is focused and transformed into usable information (Miles and Huberman, 1984). This is by done grouping the data to uncover *themes* which permeate various aspects of the fields. The analysis process concludes with organizing the remaining data in an appropriate format (data display) and then drawing conclusions from that data (make conclusions). This process is done repeatedly with preliminary ideas spurring follow-up collections, reductions, and displays.

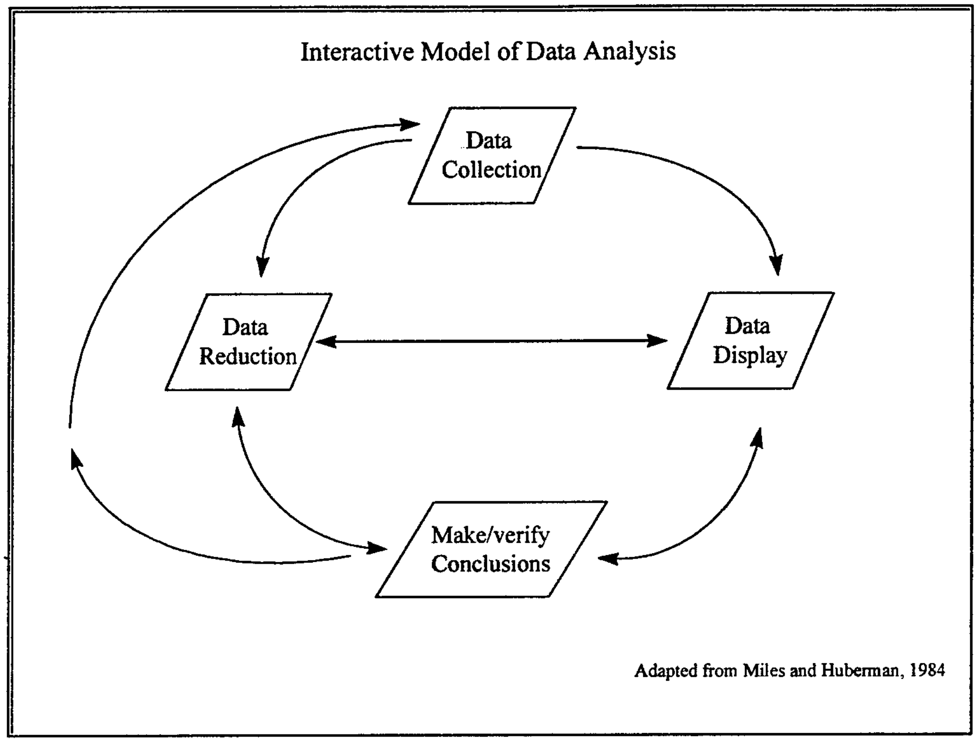


Figure 7. Interactive Model of Data Analysis
(Miles and Huberman, 1984)

Data Collection. During this phase, primary emphasis was placed upon gathering information on the three major aspects of the research: information warfare, information resource management, and decision-making (See Figure 8). Data on the OODA Loop was kept at the center of all collection efforts. The objective of this was to investigate how the three aspects reflected or impacted the OODA Loop. Secondary searches centered on exploring how decision-making and IRM could be viewed as *legitimate* aspects of information warfare.

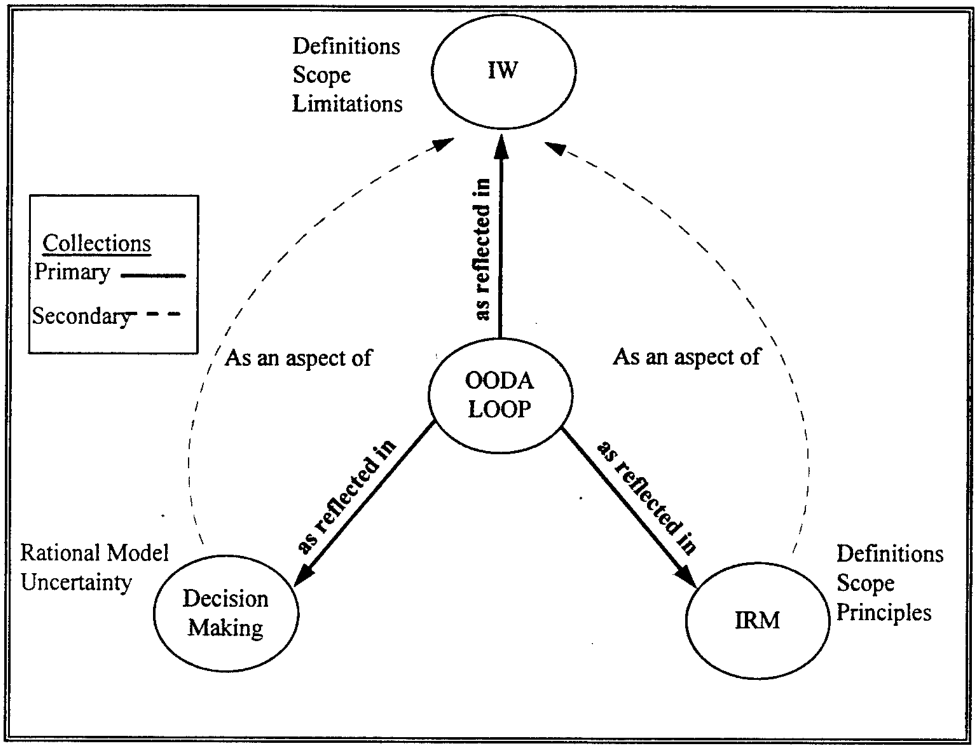


Figure 8. Data Collection Approach

Preliminary explorations began with indices such as the Reader's Guide to Periodical Literature for the years 1980-1995. It was felt that information in the years prior to this would yield minimal information pertinent to an electronic information system. Cursory examinations in some of the earlier volumes proved this to be the case. Listings were found in the 1980-1995 time frame, yet even these produced negligible information.

Having found little in the printed indices, on-line databases provided most of the initial information leads. The FirstSearch information service was the successful starting point for the literature review. Through it, the WorldCat, ArticleFirst, and ABI/INFORM databases (among others) cover over 12,500 journals. These databases supplied many of

the references cited in this research. Inquiries were done under the following search terms:

IRM
information resources management
information warfare
command and control warfare
decision making
OODA loop
Asymmetric Fast Transient
Boyd
rational models
information technology
information systems

The initial literature review was conducted in January 1995. Subsequent searches were done bi-weekly to ensure inclusion of newly published material. The World Wide Web (WWW) served as the final information source. The researcher initiated queries using Lycos, Magellan, the World Wide Web Worm, and AltaVista as the primary search engines. Particular attention was given to searches of military libraries such as The Air Force Institute of Technology, The National Defense University, the Defense Technical Information Center, and the Naval Post Graduate School. Weekly browsing using the aforementioned sources was accomplished to ensure currency of the material presented here. This was an attempt to accommodate the relative impermanence of the WWW links and sites.

The sheer volume of responses afforded by the search engines was a significant obstacle. It was common to get over a thousand responses per query; occasionally the number would rise to over ten thousand. Several tactics were employed to cope with this. The first was to search using advanced Boolean queries, employing multiple criteria from

the previous list. A second approach was to have the responses ranked according to some term supplied. For example the responses to a search on *decision-making* would be ranked on the term *rational*. Those citations including *rational* would be listed first. This method afforded maximum flexibility without losing information. The third approach was to use search engines which would allow numerical ranking of the responses. Any hit scoring below 500 (on a scale of 1000) was not investigated. At the conclusion of these efforts, the responses were evaluated based upon a manual examination of 1) the title, 2) the author, and 3) the reference location (URL).

Data Reduction. The task after data collection entails "selecting focusing, simplifying, abstracting and transforming the raw data," (Miles and Huberman, 1984:21). Once the material had been gathered, it was grouped into themes.

Table 5. Data Reduction Themes

- IW descriptions of the OODA Loop
- Definitions of information warfare
- Treatment of information as an organizational asset
- Historical evolution of IRM
- Definitions of information resources management
- Rational theories of decision-making
- Depiction and/or /descriptions of Col Boyd's theories
- Decision pace vs. quality

The data was assigned to the theme(s) it appeared to support. New themes were created for data which did not fit pre-existing ones and the grouping process was repeated. This continued until all data was accounted for under themes which accurately described its content.

Data Display. After the groupings had been accomplished, information was assembled in a manner that permitted drawing conclusions and taking action (Miles and Huberman, 1984). This was accomplished through creating a conceptual framework of the data. This synthesis resulted an information processing model which depicted the flow of data from the environment to the decision-maker. Chapter four discusses uses of this model.

Summary

The information processing model provides the means for identifying places where the application of information resource management principles can serve to improve the overall decision-making process. The premise being that if military leaders must make their decisions based upon information systems, then the role for IRM in IW is improvement or constriction of the decision-making cycle. The next chapter discusses the propositions *(conclusions)* drawn from integrating the information processing model into the OODA Loop.

IV. Analysis

Introduction

This chapter presents an analysis of the data gathered within the scope of the research questions and a discussion of the findings resulting from this analysis. It is presented in three sections. The first section presents the information processing system model. The model is explored as a means for gaining greater insight into the OODA Loop and by doing so, the decision-making process. The second section introduces a series of propositions which identify methods for accelerating completion of a particular stage in the decision-making cycle. Each proposition is examined from three standpoints: How is it derived from IRM? What premise does it put forth? What are those IRM tools which are pertinent to implementing it? The third section describes decision quality as an under emphasized aspect of the OODA Loop. This is done by illustrating the tradeoff between speed and quality in the decision-making process. It follows with offering an augmented version of Boyd's OODA Loop which captures the quality of the decision as well as the speed at which it is made.

The Information Processing System Model

Decision-makers depend upon their information systems to provide them the details necessary to accomplish the mission. However a limitation inherent in any system is that it cannot capture the universe of data. Thus, from the very start, information systems are effectively limited in two manners; figure 9 presents the Information

Processing System model (IPS) which depicts these limitations. First, since it is not feasible to collect everything, most data never enters the system. Second, when IS professionals and planners recognize this fact, they incorporate data collection filters into the IS. These filters are intended to maximize the opportunity that the subset of data actually gathered by the system is useful. However, problems occur when such filters are poorly constructed either due to bad design, an inability to identify the significant information, or an evolution of the environment with its concurrent change in data collection needs.

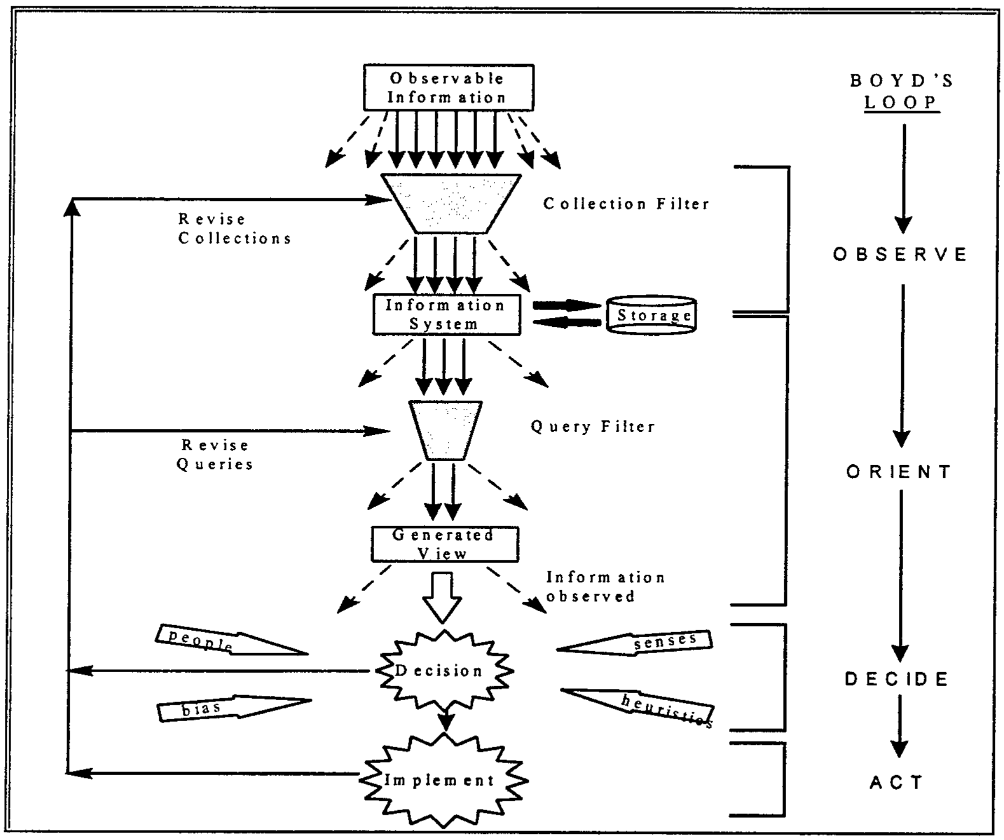


Figure 9. Information Processing System Model

A second set of filters is encountered as the user interacts with the system. When the system replies to a query, it does so through presenting information that matches the user-prescribed specification. The information is once again effectively filtered to an even smaller subset due to 1) the presentation (formatting) of the data and 2) the ability of the user to adequately describe his needs. The end result is that the information actually presented to the decision-maker is drastically diminished. The decision-maker who is unhappy with the results of his interaction with the system must change either the collection filter (gather the right information) or the query filter (resubmit another query).

IPS and OODA. This model can be further used as a framework for examining how to leverage information warfare. This thesis uses Boyd's OODA Loop as its initial model of IW. While this is a viable way to *view* decision-making, it fails to provide adequate details to *improve* it. What is needed is a comparable model, which provides greater detail while still remaining true to the OODA Loop's essential characteristics. This is contributed by the IPS model.

The Boyd's OODA Loop is superimposed on the information processing system model at the right side of figure 9. The loop's four stages can be correlated to the related sections of the IPS. Collecting and storing data are comparable to observation. Orientation is then the process of interpreting the data through repeated queries and view generations. The decision steps are identical. Finally, the communication of the decision such that it can be implemented is equivalent to Boyd's act.

The Electronic Battlefield: An Illustration. The electronic battlefield is a facet of IW where military leaders depend heavily upon computerized information systems and the use of near real-time information in battle. This vision of the future can be used to illustrate the implications of the model in Figure 9. A system employed under such circumstances, theoretically, would be designed to only capture information valuable in a military setting. Most information is left out by choice and remains in the external environment. Furthermore, the decision on what information to include or not is done *a priori*, based upon what planners had been deemed important *in the past*. During battle, an officer who wants to have current reconnaissance photographs may not be able to acquire them if the need wasn't previously identified. His system would simply not be designed to support it.

Information filtering occurs a second time when the officer interacts with the system. It is incumbent upon *him* to know the correct question to ask. The aforementioned photographs will not be available if he either does not know they exist or barring that, does not know how to retrieve them. Furthermore, filtering becomes a function of the view generated by the system. Suppose our officer now wants information on battles occurring during the past 72 hours. If he selects a graphic output, trends may be discovered, but he will lose details such as the intensity of the battle, number of troops and armor involved, etc. which might be included in a textual output. On the other hand, if he decides to get a report, he may have to endure reams of

unimportant details to the detriment of his grasping the bigger picture. At this second layer of filtration, much of the information can be lost due to user-attributable factors.

Users who fail to get the requisite information can be provide feedback to the system in one of two ways. First, they can initiate revised queries related to the initial ones. Our officer, recognizing his graph only provides the location of the battle and none of the details, may query the system to provide an additional report with that information. If this and subsequent revised queries are successful in providing the needed information, the feedback will end. However, if they are not, it may be because those particular information requirements were not foreseen in the past. Reconnaissance photographs may not be available to the field officer because no one thought personnel in battle would want the actual photograph. In order to get it, the system will have to be adjusted to reflect this new requirement. This is the essence of the second part of the feed back loop: revised collections. It is the recognition that not all information can be captured and occasionally it will be necessary to adjust what the system collects.

Constricting the OODA Loop Through Increased Efficiency

This section examines how to improve the speed at which decision-makers traverse Boyd's OODA Loop. Each phase of the model is presented together with an analysis of how it can be expedited via using IRM principles.

Observation. Observation, the initial decision-making phase, refers to the necessity to scrutinize the environment and, by gathering relevant data, to determine the

circumstances under which one must function. The pace at which observation can be accomplished is a function of two factors. First, how much data does the human or information system capture from the environment at any point in time during observation? Second, how many times must the collection filter be adjusted to capture data which the orientation phase identifies as necessary, but being missed?

<u>Proposition 1</u>. The time required to accumulate sufficient observations can be shortened by maximizing the amount of pertinent data entering the IS

Proposition 1 originated in an examination of how IRM principles could conceivably shorten the amount of time needed to accumulate enough observations for decision-making to move into the orientation phase. The significant aspect of this observation is to collect sufficient *pertinent* data to create an accurate mental image. Three IRM principles cited in the preceding chapters were combined to form the basis of this proposition: 1: *Support decision-makers via readily available, accurate, and timely information*, 4: *Link strategic information planning to support of organizational objectives*, and 7: *Involve end-users in all stages of the information life-cycle*.

The gist of principle 1 is that decision-makers require information, upon which they can rely, in a quick fashion. The task of information resource management is to tailor information systems such that users can access that correct information rapidly. However, to do so requires both an understanding of the needs of the user and the direction of the overall organization. IRM principle 7 attempts to *involve* end-users in planning their information needs; principle 4 binds information related efforts to support

of those needs. Proposition 1 evolved out of the need to understand the needs and directions of the organization and the requirement to somehow capture the data it needs in a timely fashion

Obtaining the information can be done either *grossly* through increasing the total amount of data entering the system or *precisely* by trying to raise the percentage of pertinent data in that which is presently captured. An ideal approach would likely utilize a blend of the two where more data is collected and a higher proportion of that is pertinent. The principles of IRM discussed in chapter two were examined in this light to see where they could be applied to achieve the goal of getting more pertinent data into the IS.

It is impossible, and even undesirable, for information systems to collect *all* the data present in the environment. As such, collection filters (presented again in Figure 10) are utilized to extract an appropriate or possibly diagnostic *subset* for processing. These collection filters represent sensors created to be attuned to a specific subset of data, e.g. satellites capture which record still-video only. They provide a focusing action for data accumulation; efficiency is then a measure of the signal-to-noise ratio they achieve. If these filters are perfectly constructed, all of the pertinent data is captured and nothing extraneous accompanies it. On the other hand, if they are poorly made or adjusted, so much extraneous data is encountered that the system is unable to adequately function under the weight of its noise. Between these two extremes are well-designed filters ensuring that most of the data entering the system is pertinent and usable for later

decisions. Since each sensor type is sensitive to a subset of all data, having the appropriate sensors providing inputs is vital.

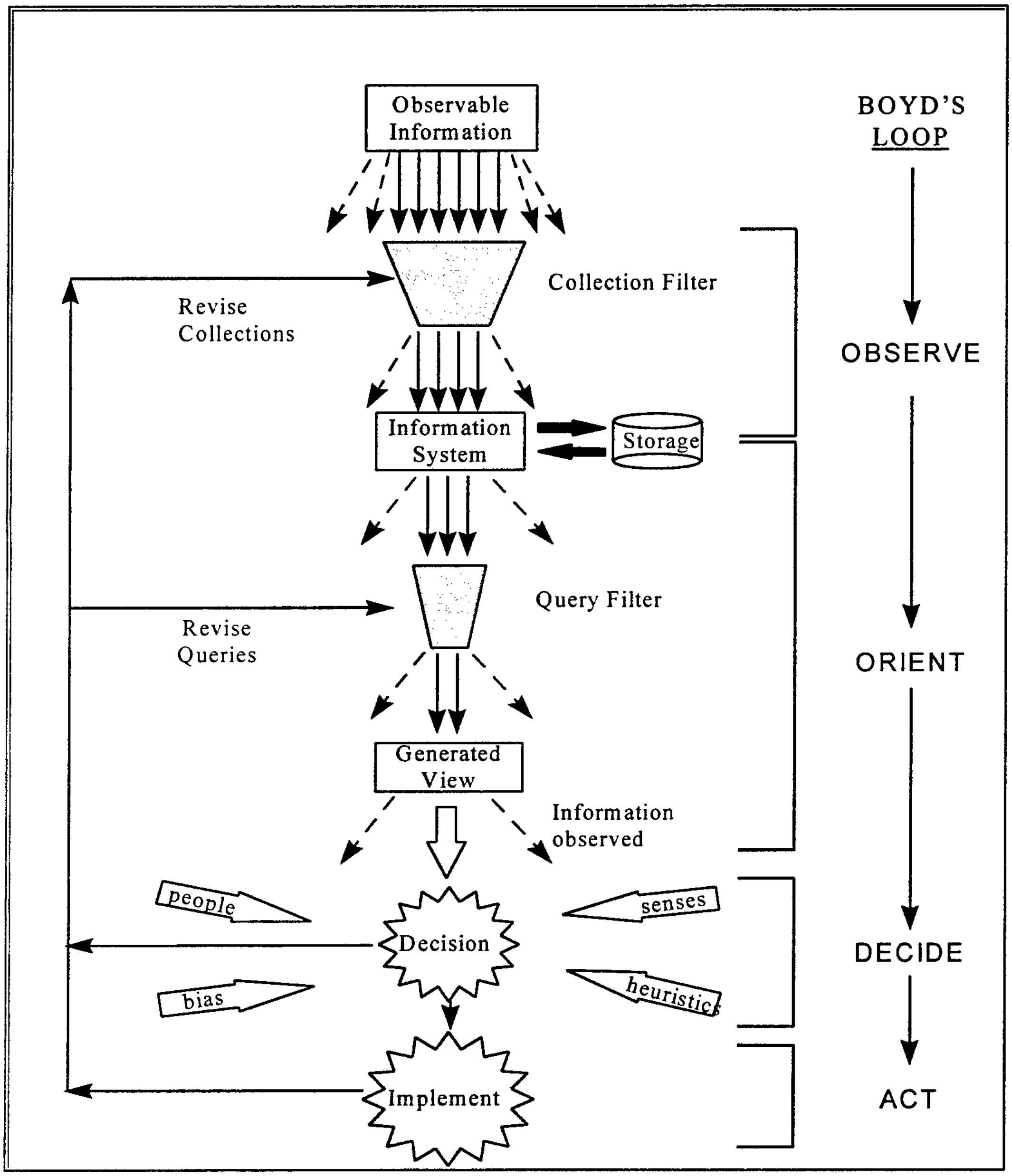


Figure 10. IPS Model

Figure 11 depicts two versions of the collection filter in an information processing system. The upper illustration indicates the status quo. There is a given amount of observable data within the environment. However, not all of the data is desired. That which isn't desired is considered within the context of the IS to be merely noise. The collection filter captures a subset of all the data, some of which is pertinent and some of which is noise. In the lower illustration, the collection filter has been both augmented and improved and storage facilities have been increased. Augmentation brings greater *amounts* of data into the system. Improvement increases the amount of *pertinent* data within that collection. This ensures that more of what is collected is actually matters and meets the information needs of the decision-maker.

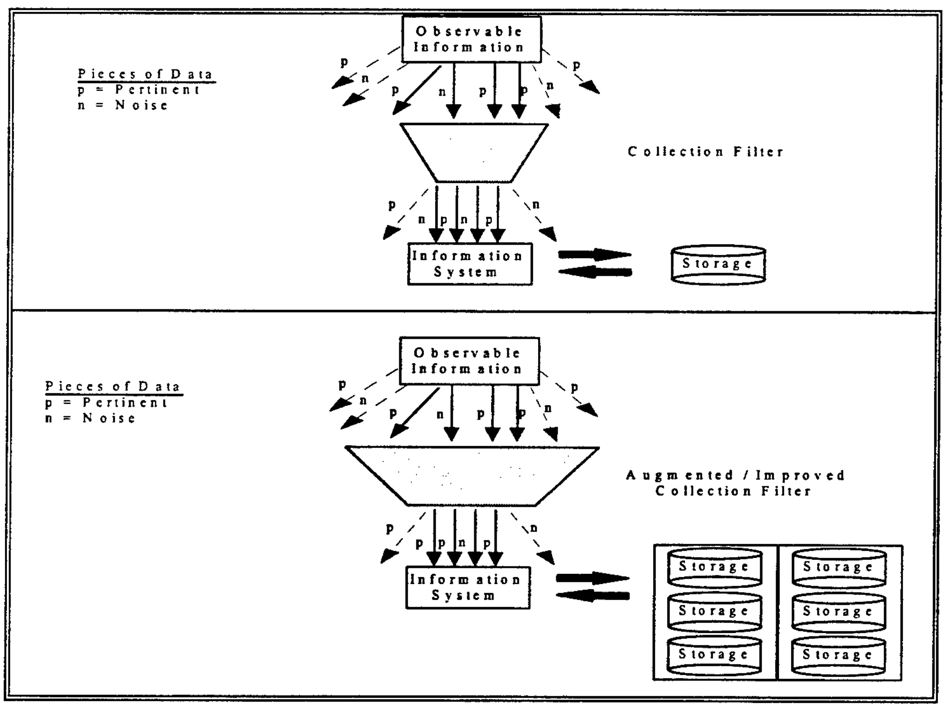


Figure 11. Improving Collection Filters

Ambiguity surrounding what constitutes a sufficient amount of data to collect is a barrier to quick completion of the observation phase. In the past, economics has played a part in that decision. With the recent radical decrease in storage prices, this is no longer the case. Collection filters need to be relaxed such that greater amounts of data can initially enter the system and so reduce the amount of time needed to collect data identified as necessary, but presently uncollected because of previous fiscal constraints. While the ability to afford increased data storage facilities is generally a positive factor, it does complicate the problem of sorting pertinent data from its surrounding noise.

The data collection heuristic needs to evolve from what we can *afford*, to what will decrease the time necessary to obtain the *right* data. Proper application of IRM principles can help this occur. The emphasis in data collection needs to evolve to: what is the most effective way to decrease the time necessary to collect data? While it is possible to alter an existing system to process a different type of data that it currently does (create a new collection filter), it requires a substantial cost in terms of both time and dollars. Dollar costs aside, the time needed to create a new filter can expand the observation phase past the point of acceptability.

It is time-cost effective to design the system filters to collect the maximum amount of pertinent data which is feasible. Increased collection has only recently become practicable, due to the cost of storage dropping to such a extent that the trade off between cost and collection now favors higher collection. This does not mean that all the data is presented to the decision-maker, merely that it is all available to respond to his queries should the need arise. Having a larger subset of the data from the environment minimizes

the chance that the user will need to change the collection filter. In doing so, the expensive time-costs associated with redesigning a collection filter are avoided and observation time is decreased.

IRM can help describe how to design these filters and accomplish proposition 1. In order to collect the most pertinent data it must be identified so that the system can be structured to capture it. IRM works in this regard by keeping users intimately involved in the development of their IS through using rapid prototyping during system development. In this methodology, information systems are created incrementally. At each iteration, users interact with the system and provide feedback to the IS professionals. Both positive and negative comments are solicited so that the system can be tuned to the needs of the user. Utilizing such high user involvement, the collection filters can be designed so that they most closely capture data which reflects the users needs. This leads to the creation of collection filters which provide data with a stronger signal-to-noise ratio. Less alterations are necessary because the system captures more of the pertinent data from the start. The following is a short narrative illustrating proposition 1.

An innovative application of commercial technology is currently being deployed to military forces in Bosnia. One of the goals of this information system, developed by the DoD and the CIA, is to increase the amount of intelligence and command related information quickly available to troops actively participating in the conflict. It utilizes 30-inch satellite dishes and a small amount of hardware to connect troops at the front with vital data sources such as the Pentagon and the Defense Mapping Agency. The new IS utilizes existing private-sector technology (satellites and fiber optic cabling) to provide

millions of gigabytes of data to terminals carried troops on the ground (Mathews, 1996). The change this brings about is astonishing as can be seen by the change in air tasking orders.

> During the Persian Gulf War, USAF air war commanders couldn't deliver air tasking orders via computer to the Navy because the Navy's systems were not compatible with those used by the Air Force. The daily tasking orders, a phone-book-size list of targets to be bombed and units to do the bombing, had to be delivered by helicopter each day to Navy aircraft carriers. No more, defense officials proclaim. Now air tasking orders can be put on the military's new internet, or "web," to be downloaded by anyone who needs them. "It's available to anyone who's got a 30-inch dish [antenna] and a set of decryption equipment," say Pentagon officials. They say they are confident that encryption will keep secret information unavailable to enemies.
>
> Weather data, maps, photos and video from aircraft, "huge amounts of imagery" that overloaded electronic transmission capabilities during the Gulf War, will flow like a vast electronic tide in Bosnia, the Defense Department promises. In fact, the availability of vast amounts of information may become a problem in the future. Already, "the feedback is, there is so much information it is hard to sort through it," Blair said. From "fly through" maps to threat summaries, foreign broadcast transcripts, logistics updates, contingency plans, reconnaissance, battle damage assessments and more, the military's web users will be inundated with data. To help them cope, the Defense Department has created "manned and unmanned anchor desks" at a "joint information management center" at the Pentagon to receive information requests from troops in the field and sort through data to provide relevant information. The anchor desks also will assemble intelligence summaries and put them on the Pentagon's web "so troops in the field can pull down what they need." The result, the info warriors hope, will be greatly improved situational awareness. (Mathews, 1996)

This illustrates the premise behind proposition 1. Intelligence gathering is a difficult task at best. One of the complicating factors of the process is that after data has been gathered, it must be relayed to those who would make decisions based upon it. In the past, this has been a bottleneck in information gather as the air tasking example

relates. However, the IS being deployed to Bosnia directly addresses that problem. It increases throughput dramatically, that is the pipeline carrying data from staff agencies has widened to the point that the time needed to gather pertinent data is decreased. This has lead to improved decision-making due to augmented situational awareness.

The filtering action in the Bosnia illustration was late coming. The USAF initially increased data collection grossly through implementing the web system. The data became glutted and a low signal-to-noise ratio resulted. Collection filtration in this system occurs in two areas. The first is the creation of a *military* web. The World Wide Web has thousands of nodes. Were the system merely allow troops to utilize it, they would experience difficulty locating the information they needed e.g. terrain maps. However, the information on military web has already been deemed to have significant military value and so an initial filtering activity has already occurred. The second filtering occurs through the use of joint information management center. This Pentagon office filters the information further by relaying information specifically requested by front-line troops, as well as, performing general summation and relevance checks. Actions such as these allow users to spend less time extracting useful information from the noise that surrounds it. In doing so, the time the require to accumulate sufficient observations can be decreased.

<u>Proposition 2</u>. **The time required to accumulate sufficient observations can be shortened by changing the organizational structure concerning information from emphasizing information ownership to information stewardship.**

This second proposition evolved from principles 1: *Support decision-makers via readily available, accurate, and timely information*, 3: *Cultivate horizontal as well as vertical information sharing*, 4: *Link strategic information planning to support of organizational objectives*, 8: *Emphasize information stewardship not information ownership*, and 9: *Exploit information technology to benefit the organization* were merged. Together, these speak to the ability of information sharing to affect the speed at which observation takes place. If information system components (human and machine) contain barriers to information flows, removal of them would increase the speed at which sufficient observations can be accumulated.

Addressing these barriers from an IRM perspective leads to a second way to decrease observation time by creating a structure within the organization which stresses information stewardship not information ownership. Stewardship entails the fostering of growth and utilization of the information resource. In contrast, ownership does not. Information ownership is concerned more with power structures and rights. Information needs to be viewed on a higher level than has been possible in the past when an information ownership view was espoused. Whereas Proposition 1 dealt with increasing the amount of pertinent information which is collected, this proposition proposes accelerating observation by having access to all of the information which is *currently* collected by all of the areas in the organization in the shortest time conceivable. Presently, this ability is not widely implemented.

Traditionally, the military structures information around the squadron, group, wing, etc. Its legacy information systems are designed to support such a view. In IRM

however, information is an organizational asset in a larger sense. Information primarily supports the overall corporate-objectives and so the IS is designed with the larger requirements of the organization in mind. It is not centered around the needs of the myriad subordinate units. Figure 12 graphically depicts how the present approach results in an information system different from one incorporating IRM principles.

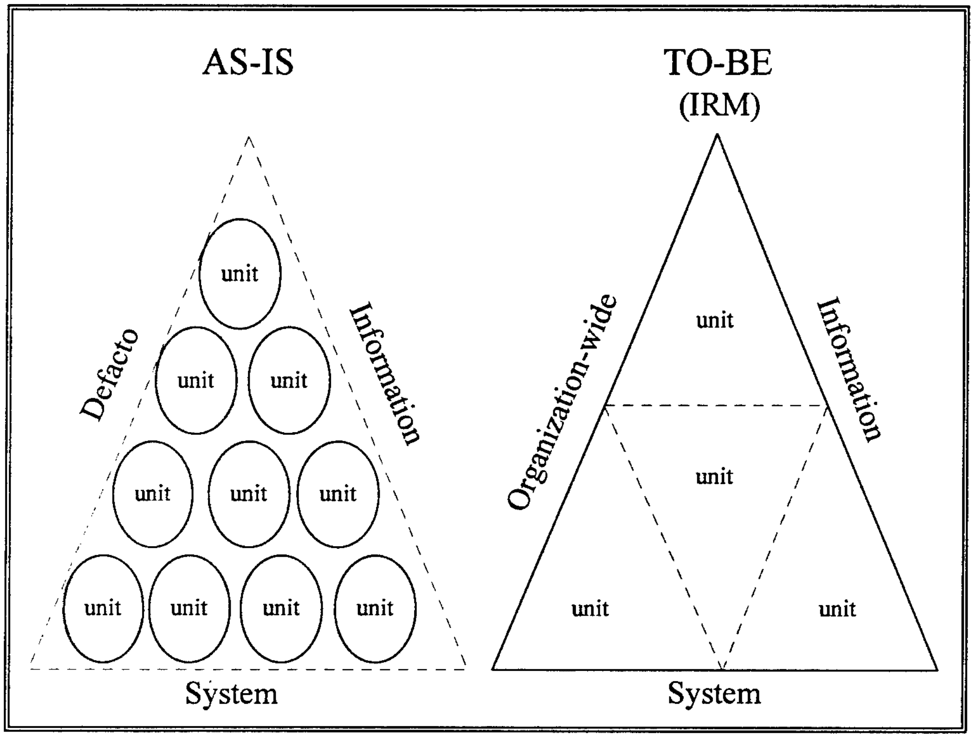


Figure 12. Different IS Approaches

The "AS-IS' illustration on the left shows an organization whose information systems are structured around a low level. The circles depict ISs of the various units below the organizational level. They are autonomous, not based upon common data standards, and generally do not share information. No overall IS exists, beyond the amalgam of disparate unit information systems. The "TO-BE" illustration on the right

depicts how a system incorporating IRM principles would look. The lower systems are subordinate to a higher organization-wide IS. Their boundaries, as indicated by the dotted line, can be set up so that they are permeable. In such a system, the subordinate units would share information and store it in a large corporate database(s). In effect, the unit information systems would cease to exist as separate entities. They would instead be extension of the overall system which had been tailored to meet their needs.

The primary difference in the two approaches is one of alignment. Presently, information is structured around a relatively low level of the organization. The individual systems are designed to support smaller units and there is a lack of an corporate information paradigm. Self sufficient, little information sharing is feasible and there is minimal capacity to support other areas of the organization. Under an IRM approach, there is no lower-level data ownership. Information belongs to the entire organization and is structured accordingly. This increases information flow by allowing data and application independence. Uncoupling these two is a step towards having data which can be utilized by multiple applications (possibly located in different functional areas) and reducing the amount of data redundancy which occurs because the same information must be stored in multiple locations.

Such a change requires that information managers at all levels of the organization link their efforts to the larger plans of the organization. Strategic information planning, tied to the overall needs of the organization is a step in the right direction. What is needed is a alteration of the way managers view information. It is not a resource of the individual, nor the unit. It belongs to the overall organization. Only through

implementing this particular mind set will information end up flowing freely throughout the organization. IW demands that personnel move to a new paradigm and look at information on a larger scale.

IRM has several tools to further the accomplishment of Proposition 2. The most basic of these tools is the strategic information plan. This document can describe what information is needed by the organization, identify where that information can be found, and then ensure information standards are in place to couple the two. Use of a strategic information plan helps broaden the perspective of mangers to see beyond the parochial world of their functional department, to focus on their place within the larger scheme of the organization. It is a step toward helping them to see what they own nothing because everything ultimately belongs to the organization, information included.

The next major IRM tools are personnel functions. These are the Chief Information Officer (CIO) and, below him, the Data Administrator. The CIO serves on the board of directors and works all areas of information policy. Much as the Chief Financial Officer is tasked with ensuring adequate control of financial assets, the CIO ensures that information assets are managed in a manner which optimizes their utility. Further down on the organization chart is the Data Administrator (DA). The DA, is the steward of the information within the information systems. His responsibilities involve development and implementation of the overall plan for collecting, storing, using information. "It is predicated on the understanding that information is crucial resource and as such, plans for its use must be developed in a context of overall organizational needs" (Heminger, 1996). Establishing either or both of these positions and imbuing

them with the authority to act on their realms of responsibility will take a large stride toward changing the way the organization views its information.

A 1995 evaluation of the information systems at the Air Force Institute of Technology (AFIT) can be used to illustrate the premise of Proposition 2. The evaluation was conducted during an examination into the feasibility of implementing an executive information system (EIS) at the institute.

> AFIT's EIS was intended to aid the AFIT Commandant with problems encountered when responding to various information requests accomplished on his behalf. Often the information proved difficult to locate, particularly in the desired format, and much time was spent looking for it. Further, similar requests often resulted in inconsistent responses, leading to confusion and additional time spent trying to reconcile the different responses. Frequently, the difference in responses could not be adequately reconciled.
>
> Upon investigation of these difficulties, several problems surfaced 1) Lack of knowledge about where information is stored; 2) Lack of knowledge about using the information systems that are available; 3) Difficulty using some of the information systems that are available; 4) Lack of a comprehensive plan for information management within AFIT; 5) Lack of a clear authority for information management policy; and 6) Lack of an Executive Information System to support information requests.
>
> The splintering of information into widely scattered databases leads to a diffusion of accountability. Work centers too often focus on their individual concerns without a holistic appreciation for how their information fits into the overall data structure. This leads to the perception that AFIT's corporate information resources do not belong to anyone in particular. Therefor no one is identified as the responsible party for ensuring the uniformity, currency and accuracy of the vast array of information that is captured daily throughout the institute. (Heminger, et al, 1996)

At AFIT, information stewardship was not practiced. Individual directorates were concerned with their own particular piece of the information pie and their was no overall system to which the commandant could turn. As such, the information supplied by this

organization was disjointed and often contradictory. Inquiries tended to take extended periods of time, much of which was consumed to ensure that the information which was supplied to the senior staff was correct and up to date.

Improvement in the time required to gather *accurate* information is readily found when the need to constantly cross check inquiry results in eliminated. Information stewardship, with the reduction in data anomalies it brings, addresses this. In fact, recommendations in the AFIT report call for the creation of data administrator and database administrators positions. These two, as previously discussed, are a first step toward creating a structure where members foster information because it really belongs to the overall organization and they are but its caretakers.

Proposition 3. The time required to accumulate sufficient observations can be shortened by structuring organizational data such that it can be more readily accessed by multiple systems.

The final observation-related proposition is an amalgam of five principles: 1: *Support decision-makers via readily available, accurate, and timely information*, 3: *Cultivate horizontal as well as vertical information sharing*, 4: *Link strategic information planning to support of organizational objectives*, 8: *Emphasize information stewardship not information ownership*, and 9: *Exploit information technology to benefit the organization.* These are core IRM principles. Ideally, an organizational information system structured around them could be expected to be completely interoperable. This interoperability come about via an elimination of compatibility barriers. Computability

barriers are heterogeneous software and hardware inventories which prevent IS connectivity. Removal of them would result in an increase in the capacity for information gathering and speed the time needed for information to reach the decision-maker.

Current stand-alone systems impede information flows because they are based upon disparate and often incompatible data standards. Information residing in one system is not formatted to be processed by the software of any other. Consequently, decision-makers needing information from several different areas of the organization are forced to accomplish multiple outings to other units to obtain necessary information. Figure 12 depicts such a system. Here, the four organizational units each have their own database which contains information they use in performance of their functions. None of these are interconnected and the overall system is extraordinarily sluggish. Even a simple system as depicted in the illustration requires three separate inquiries to collect information scattered across the organization. For example, if Unit A was gathering information for a report on troop levels, workers would have to investigate databases located in Units B, C, and D before all of the information could be accumulated. Valuable time is needlessly lost because the hardware and software are incompatible.

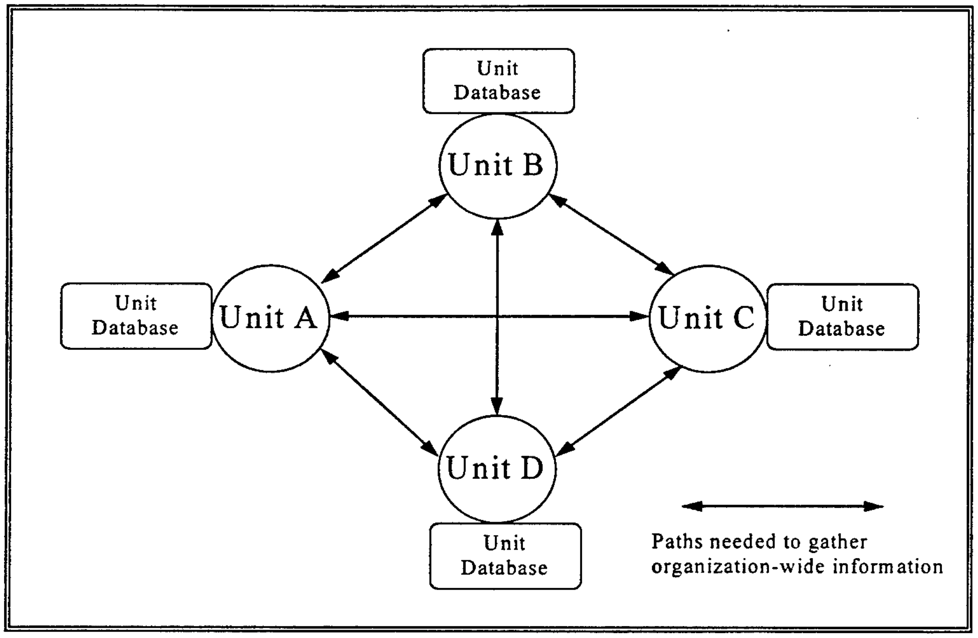


Figure 13. Current Data Sharing Approach

A system employing IRM principles would provide greater information utility to the user by having all of the organization's data accessible. An corporate data warehouse serves both as a repository of historical information and as a means of integrating various organizational database. In the information warfare arena, information must be structured such that it can be transmitted between systems in real time. This can best be implemented by an data warehouse

> The data warehouse model is a new and immature database concept, which is itself, a new information technology architecture. Data warehouses provide a framework in which to perform data mining, which is the discovery of useful patterns in massive databases with mass collections of data stored in tertiary storage for the purposes of driving decision support systems. The data warehouse is a subject-oriented corporate database which deals with the problem of having multiple data models implemented on multiple platforms and architectures in the enterprise. What many corporate computer users understand is that the key to identifying corporate threats and opportunities lies locked in the corporate data which

is often embedded in legacy systems on obsolescent technologies, and they realize that the businesses needs to get at that data today (Noel, 1996).

Figure 14 describes a way of implementing this tool. However, it would, in turn, depend upon the existence of enterprise-wide modeling. This type of modeling is "a logical map of data of an entire organization which represents the inherent properties of the data independent of software, hardware, or machine performance characteristics," (Martin, 1989b). Using this would assure that common data models are employed across the organization systems and thus information collected by one can be readily accessed by others since it is stored in the same format. In lieu of that, the system could capture the models in use by the subsystems (databases). Users can then interact with one system and obtain all the information stored and available within the organization. As can be seen in the figure, the amount of querying needed to gather data is markedly smaller that that found in figure 13.

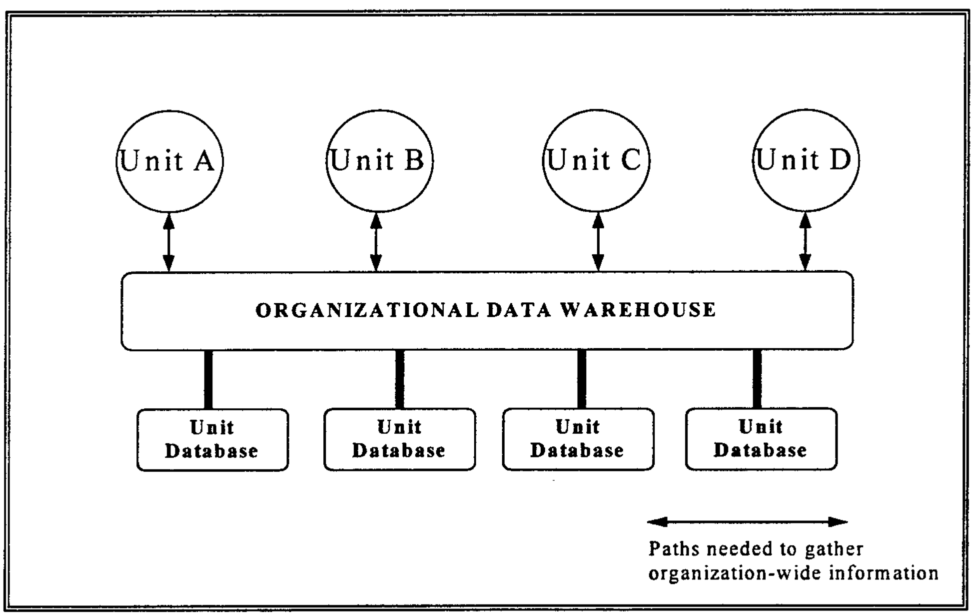


Figure 14. Data Sharing Under IRM

Enterprise-wide data modeling and information warehouses are manifestation of information as an asset of the larger organization. These can be used to expedite observation by ensuring information captured by the organization is readily accessible by those who need it. Proper management of the information technology and interoperable systems, based upon standard data models, can further this goal. Since IRM is tasked with ensuring that the organization is structured to get maximum benefit from its current information hardware and software, this is one manner in which it can directly impact the mission through shortening the time necessary to grasp the information already in the organization.

The Global Transportation Network (GTN) currently under deployment can be used to illustrate Proposition 3. GTN is a response to a perceived need by the US Transportation Command for greater visibility during logistical support operations.

> The role of GTN is two fold. First it is an integrated, automated, command and control information system. It serves as a central repository which can be used to support decision-making in a global environment. Secondly, it is designed to collect, consolidate, and integrate the status and location of military cargo, passengers, patients, and lift assets from multiple DoD and commercial transportation systems. It is expected to provide a standard method of tracking material throughout the transportation pipeline by linking the many various systems currently used in the other branches of service and participating commercial carriers. (Wolford, 1996)

The system is similar to those used by such commercial corporations as Emery Worldwide, United Parcel Service and Federal Express in that each of these is concerned with the tracking of material flowing through the organizational pipeline. GTN is the DoD incarnation of this form of logistics service.

The system strives to achieve what is appropriately called In Transit Visibility (ITV). At the core of ITV is the ability to identify available personnel and materiel at any time. However, in order to achieve this task there are hurdles which must be overcome. One of the major ones, of particular concern to Proposition 3, is the lack of interoperable systems and common data standards between the various services and commercial carriers. The latest version of GTN consolidates command and control, transportation, and logistics data from Air Mobility Command, Defense Logistics Agency, and Military Traffic Management Command into a single database (Wolford, 1996). This repository is then accessible by any user who has been issued an account by the system administrator at USTRANSCOM.

While other case have dealt with evident problems which can be addressed by a proposition, this one is the opposite. The GTN illustration shows the proposition from the other angle where it has been implemented (although not intentionally) and the proposed benefit materialized. GTN is, in essence, a form of information warehousing where information from throughout the organization can be accumulated and then interpreted. Prior to its implementation, DoD was had to rely upon slower methods which could not provide instantaneous information on the status of personnel and materiel. GTN changed that by adapting the commercial notion of other carriers, such as UPS, which claim to be able to tell its customers where their package is located 24 hours a day, 365 days a year.

Orientation. The core of the decision-making process is *understanding* the circumstances of the environment in which one finds oneself (Boyd, 1987). It can be an exceptionally difficult decision-making step to improve and yet, one where significant potential gains can be realized. The heart of Boyd's loop, orientation, deals with the creation and maintenance of a mental image of the world (See Figure 15). Mental images have many facets, but the main ones are Perceptions, Assumptions, and Data. When data is received which does not fit within the preconceived view of the world conflict results. On the basis of this conflict, the image is reassessed. Next, the image of the environment is adjusted to reflect the new data. It is assimilated and a new image of the environment emerges. This process is continually repeated as the fluid environment evolves.

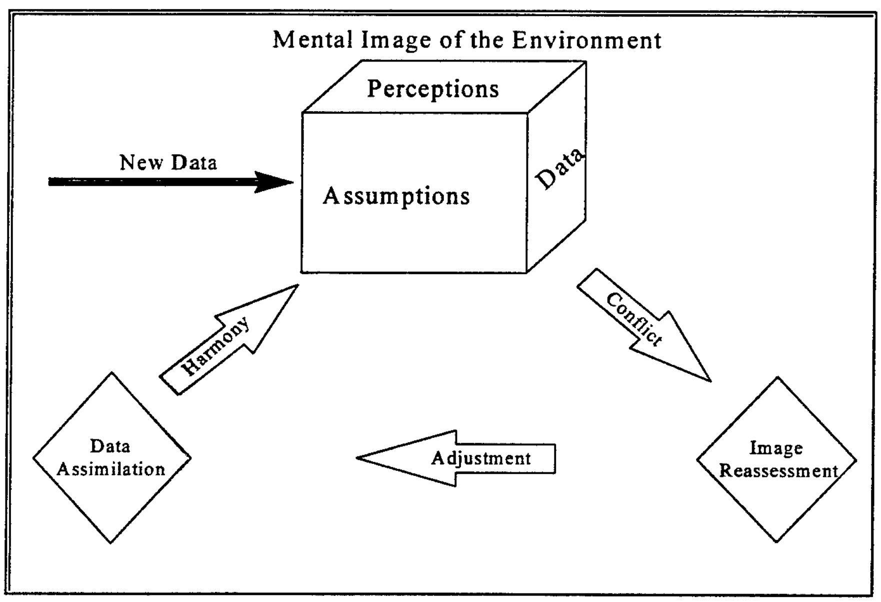


Figure 15. Expanded Orientation Process

The difficulty in improving this process lies in the relative inability to influence the assumptions and perceptions of the decision-maker with IRM tool. Data processing can be improved. Information systems can be integrated and optimized. However, the internal mental workings of the individual are difficult to manipulate in terms of increasing the speed at which decisions can be made. For this reason, improvements in orientation will be difficult to observe by addressing these factors. Instead, it is the final part of mental image maintenance and creation, data, where gains are more readily found. The reason behind this, is that IS professionals have at their hands a myriad of tools for, and decades of experience in, manipulating both data and IT. However, they are much less skilled at discovering the internal workings of people's perceptions and assumptions.

Proposition 4. The time required to orient can be shortened by minimizing the time decision-makers must spend analyzing information presented by the IS.

Proposition 4 is a product of jointly considering IRM principles 7: *Involve end-users in all stages of the information life-cycle*, 8: *Emphasize information stewardship not information ownership*, and 9: *Exploit information technology to benefit the organization.* Together, these speak to the need for information systems to be easily understood and used by the decision-makers and their staff. Aligning technology with the needs of the users and structuring systems around their needs can decrease the amount of time consumed by decision-makers in interaction with the resulting ISs.

Significant amounts of time are required by users to overcome poorly designed interfaces and standardized outputs which do not fit their needs. IRM can accelerate

orientation by reducing the time decision-makers spend interacting with the system while attempting to understand the information presented by it. This differs from observation where the emphasis is on the gathering of data. Orientation is the transformation of that data into information used to create and/or modify the mental image. IRM's contribution to accelerating this process is to tailor the information systems to the user rather than the other way around. This is the heart of information resource management: information systems must be cultivated such that information utility is maximized.

Many legacy ISs were designed with insufficient emphasis placed upon finding out the ease with which users could readily extract information. To the laymen, the slogan of information professionals appears to have been bigger-faster-better. Their systems function well in the sterile vacuum of the IS department, but all too often fail to adequately perform outside of that restrictive environment. Users often encountered difficulties in interacting with the system because their needs were not central to its design.

The hastening of orientation can be brought about by creating information systems which are easily learned and used by the decision-maker. It is true that some highly technical systems are not easily learned, but once learned are very usable and effective. However, users are becoming less tolerant of such systems which are so arcane that, even though information is contained within them, it is frustratingly difficult to extract. To facilitate ease of operation, users need to be involved in all phases of the systems development life cycle. Failing to do this forces users to waste time culling information out of a an unwieldy system. Customizable interfaces, together with

tailorable outputs can speed up the rate at which the user can extract and understand the information the IS maintains.

IRM has tools which support this proposition quite well. They can be grouped into two broad areas. The first is user-tailored IS training. This entails education of the user in all aspects system utilization. It includes such things as ensuring the availability of documentation written in a fashion comprehensible to non-IS professionals, creation and education on the use of user-specific templates and macros, and fabricating user-friendly screen design. All of these are centered around making system interaction a easier task. The second grouping concerns system development. As mentioned in Proposition 1, prototyping together with a high degree of user involvement in the system development process can help the user in interacting with the system. While Proposition 1 discussed how collection filters can be affected by user inputs, Proposition 4 is concerned with the user interface. In particular, what nuances of the interface *work* for the decision-maker and which are a hindrance. Prototyping is well suited to discovering these things early on during the development process so that they can be incorporated into the system. An illustration of the potential need for Proposition 4 is found in the case of the USS Vincennes.

One of the most graphic errors in information processing occurred on 3 July 1992 when the United States Aegis Cruiser Vincennes shot down an Iran Air A300B2 Airbus on its routine course from Iran to the United Arab Emirates. A complicating factor was a failure in the information system. It was not so much that it did not provide sufficient

information. Just the opposite: too much data was being presented. The Vincennes disaster can be examined from an IRM viewpoint to illustrate the preceding proposition.

At the time of the disaster, Captain Rogers, captain of the ship, was directing a sea battle with Iranian gunboats. He, together with two other officers, coordinated the ships actions from a combat information center (CIC). It is here that all the data drawn from the cruiser's sensors is integrated into the central Aegis computer and displayed on four 42-inch-screens for the crew's response. The multi-million dollar system on the Vincennes is purported to be able to track and identify up to 200 aircraft at a range of 300 miles. It is the responsibility of this system on the Aegis to identify all airborne threats, display their vital statistics such as speed and heading, and to then to rate them based on their potential danger. The Aegis system is complex to the point that it is capable of exceeding the ability of the user to handle (Barry and Charles, 1992).

> In the full- scale war against the Soviet Union for which Aegis was designed, the captain and crew would have had little choice but to switch the system to automatic and duck. Indeed, some experts question whether even the best-trained crew could handle, under stress, the torrent of data that Aegis would pour on them. A 1988 Government Accounting Office report accused the Navy of rigging Aegis sea trials by tipping the crews off to the precise nature of the "threats" they were to face. The Navy could not afford to risk failure in the trials for fear that Congress would stop funding the Aegis program. (Barry And Charles, 1992)

In managing the confrontation with the gunboats Captain Rogers, replaced the officer in charge of the tactical display because the officer was uncomfortable with computers. The captain then focused on the gunboats by setting the range on the CIC display screens to 16 miles. Bandar Abbas airport in Iran is used by both military and

civilian flights. As such, a standing order existed to automatically categorize all flights out of it as *assumed* hostile. As Captain Rogers concentrated on the 16 mile radius displayed on the CIC monitors, the Vincennes' radar picked up the Flight 655 at 65 miles out and classified it as such.

The confusion aboard the Vincennes persisted as the ship carried on the fight with the gunboats. All the while, its electronic data flow within the CIC continued to grow to the point it became confusing. Officers and men communicated via headphones over several channels, with left and right ears usually listening to different circuits (Barry And Charles, 1992). Rogers and other ship's officers in the CIC were on a common communication circuit. However, its power was constantly being drained by sailors who tapped into it to listen to the battle. This lead to increased confusion as the officers had to sporadically change channels to stay in communication. Captain Rogers, concerned with the safety of his ship, decided that the Vincennes' fire-control radar would be locked on the plane if and when it got within 30 miles and at 20 miles it would be shot down. At 10 miles out a pair of SM-2s were launched. Thirty seconds later, they impacted and blew the left wing off the aircraft destroying it and killing all 290 passengers.

It would be overly simplistic to say that the cause of this disaster was because of the lack of time afforded to the crew of the Vincennes to react to the phantom fighter. However, what can be drawn from this case is that the Captain had a limited amount of time to make a decision. Furthermore, he was presented with so much information that it bordered on overload. What was lacking was the ability to form an adequate mental image of the scenario he faced.

Capt Rogers mistakenly shot down a civilian airliner which posed no threat to his ship. He was faced with three conflicting demands. First and foremost was the need to protect his ship. Given the tensions with Iran and the running battle with the gunboats this was a definite concern. Second, he was faced with a time crisis. At ten miles out, the ship would be within range of any missiles carried by the imaginary warplane. Finally, he had to extract data based upon a complex information system which, normally, he would not be using. It was only due to the relative insecurity of his underlings that he was placed in this position. These three factors combined to compel him to fire upon the ship when, in fact, he had oriented incorrectly and so had a flawed understanding of the situation.

<u>Proposition 5</u>. When the inputs of multiple personnel are required to reach a decision, fostering horizontal information sharing can shorten orientation time

This proposition is a blend of three IRM principles: 3: *Cultivate horizontal as well as vertical information sharing*, 8: *Emphasize information stewardship not information ownership*, and 9: *Exploit information technology to benefit the organization*. IRM seeks in all ways to support the decision-maker. However, increasingly it is not one, but multiple staff personnel which analyze the information garnered during observation. This leads to the reality where a *group* needs to form an accurate mental image. If this fails to happen, the ultimate decision-maker's actions will be flawed because they are based upon an inaccurate model as described by their subordinates.

The complexity of the world today has all but surpassed the abilities of any one individual to adequately cope with. To adapt to this environment, organizations have increasingly used group work to bring the talents of several people and specialties to bear on problems facing them. Such an approach broadens the expertise used in coming to decision and so theoretically improves their quality. However there is a price. The time needed for all the members of the team to create a shared vision of the situation is dramatically longer than one done by a single individual because of the time needed for coordination. This delay grows in magnitude as the group increases in size. A group of 3 people can communicate over 2^2 or 8 ways. One twice that large will have 2^6 or 64 different ways. It is not difficult to see how communication and coordination among all group members can dramatically slow down the ability to come to a mutual understanding of the situation (orientation).

Through facilitating horizontal information sharing, IRM tenets speed up this process. One of the primary tool supporting this proposition is groupware which, essentially, is the software implementation of this concept. Group support systems are ways in which many group processes ranging from decision-making to brainstorming sessions are accelerated. Using this type of information system, users can coordinate their work, share ideas, and interact with each other. Many of the barriers to a group reaching a consensus are overcome using such tools. Examples of these barriers are scheduling difficulties and rank consciousness or a lack of anonymity.

While group support systems are relatively low profile in the military, the concept behind them, the same one behind Proposition 5, is not. Quite simply, the complexity of

organizations and the environment they must function in has increased to the point that coordination has become surpassingly important. In doing so, this has driven a coincidental increase in the emphasis placed on horizontal information sharing. The following exerpts , a discussion of the problems associated with the coordination of multiple services during Operation Desert Storm illustrates a possible scenario for use of such a system.

> During Operation Desert Storm, the CINC made both US Army Forces, Central Command (ARCENT) and Marine Corps, Central Command (MARCENT) responsible for assessing battle damage in their areas. *If G day was to be determined after air attacks had reduced Iraqi combat strength 50 percent* (emphasis added), then ARCENT and MARCENT should make that determination since each was to conduct a major attack within their sectors. However, the problem for the joint force air component commander (JFACC) was that the rules defining a tank kill were not standardized between ARCENT and MARCENT. Battle Damage Assessment (BDA) was discussed prior to the war, but no rules were formally established between the JFACC and ARCENT or MARCENT.
>
> ARCENT insisted that the BDA would only be counted if each claimed kill was verified by the unit ground liaison officer (GLO) and submitted by separate report directly to the 513th Military Intelligence Brigade (MIB). Air Force units had GLOs, but not the Navy carrier units. Thus, the A-6 tank kills were not counted by ARCENT. In addition, the Navy felt that pilot reports were sufficient and would not send reports to the 513th MIB.
>
> Furthermore, it took the Defense Intelligence Agency one week just to assess one out of 42 Iraqi divisions. Obviously, intelligence analysts could not keep up with the pace at which coalition air was now destroying targets throughout the theater of operations. Redundancy among intelligence agencies regarding their own BDA estimates continued to raise doubts. As G day approached, ground commanders and the CINC shared divergent concerns, partly owing to faulty reporting and communication practices. (Lewis, 1994)

The problems depicted above result from having to get a consolidated view of the extent of damage inflicted upon the Iraqi forces. The importance of having an accurate count could not be underestimated since it was decided that the ground invasion (G-day) was to commence after the opponent's strength had been reduced by 50%. However, the information upon which it was based (BDA) was provided by two separate military organizations plus various intelligence agencies. Their information was contradictory because it was based on different interpretations of what a kill was. Applying the IRM principles inherent in Proposition 5 would help to alleviate some of this through the use of horizontal information sharing between all of the agencies tasked with cooperating on this mission. In doing so, confusion would have been lessened and the decision to begin G-day could have occurred earlier.

Decision. Once orientation is complete, the decision stands to be made. It calls for choosing among the alternative courses of action based upon circumstances as conceived in the mental picture. Analysis of the data reveals an area in which the speed of decision-making can be improved.

Proposition 6. The time required to choose among competing alternatives in an unstructured problem can be shortened by implementing IT tools which are tailored to the decision-maker.

The essence of Proposition 6 is found in a combination of three IRM principles 1: *Support decision-makers via readily available, accurate, and timely information*, 2:

Acquire and manage information resources in an economic and effective manner, and 9: *Exploit information technology to benefit the organization.* The majority of the time used in the OODA Loop is spent in the first half of the decision-making cycle: gathering data and processing it into information from which to mold the mental image. However, in the search to support the decision-maker, care must be given to buttressing the actual decision *itself.* That is, can information resources management assist the process of selecting among available alternatives once the preliminary information forays are accomplished? The answer is yes.

Decisions in conflict are predominantly unstructured due to fog and friction in battle. In such a situation, there exists considerable ambiguity surrounding both the environment within which they take place and the outcome they will yield. Support in this area requires a mechanism to assist in choosing among the available alternatives. IRM's tools for this are decision support systems (DSS) and executive information systems (EIS).

These tools allow decision-makers to see information at varying levels of aggregation and yet, retain the ability to drill down to get more specific information on those areas which appear more significant. Additionally, decision-makers can perform what-if analysis to get a glimpse into the effect choosing particular option might have on the decision outcome. Both DSS and EIS permit the speedy manipulation of the information presented by the observation and orientation steps. Often they are connected to some form of data warehouse so they can draw upon the organization's continuously updated current information as well its legacy data in reaching a decisions. In doing so,

both mechanisms provide means of quickly evaluating the various options and choosing among them. The following is an example of this proposition.

Relative to other IS forms, decision supports systems (as they pertain to speeding up the decision-making process) are uncommon. However, a form of one has been developed for use by pilots developing mission plans and is called *Digital Warrior*. A small system that functions quite well on today's PCs, it can be seen as a functional decision support system which enables combat units to merge intelligence data and computerized mission planning to produce mission programs. These programs are so accurate that they can be fed into to practice upcoming missions, or loaded into weapons computers when the time for battle arrives (Mathews, 1995b).

> The (Digital Warrior) system is intended to eliminate a high-tech bottleneck caused by a shortage of mission planning computers among Air Force units operating out of Saudi Arabia. The system, named Digital Warrior, brings together the ingredients essential for planning and carrying out assigned combat missions -- intelligence data, weapons specifications and information updates as the mission unfolds.
>
> The process starts with a computer that downloads intelligence data from a satellite. The data includes information ranging from weather reports and terrain features of the target area to the latest information on the location of enemy forces, enemy radar, anti-aircraft missiles and other threats. The computer uses the information to produce maps of the intended targets and the threats troops are likely to encounter en route to them.
>
> The intelligence file is used in conjunction with a mission planning program the Air Force has written that weighs threat data, target information, distances, flying conditions, weapons to be used and other factors to help pilots plan their missions. Digital Warrior provides its users with such items as ``lethality envelopes." These are visual depictions of threats posed by enemy weapons such as anti-aircraft sites. Presented as a map-based graphic, the lethality envelope around an enemy missile site shows where the greatest danger of being detected and hit is, and where it may be safe to fly because terrain, weapons range, or other factors

make an enemy hit unlikely. Thus, the computer helps plan a route to the target.

When the mission is planned, it is stored in a computer file, which is then loaded into a ``digital transfer cartridge." This is a brick-size memory device that provides information to the main flight control computer of military aircraft. If there is time before the mission, the data-filled cartridge can be plugged into a warplane simulator to give the pilot an opportunity to conduct a dry run of the mission he is about to. In addition to the mission plan, the cartridge carries data critical to the mission, such as details about the weapons the plane is carrying, fuel load, navigation points that should be passed en route to the target, radio data, IFF (identification friend or foe) frequencies and the like. During post-war sessions, both the Air Force and the Navy said they needed much greater access to mission planning computers. Now, with Digital Warrior software and a decent laptop, they can have it. (Mathews, 1995)

The Digital Warrior system can be viewed as supporting an unstructured problem in that it combines information from multiple sources, aggregates it, and identifies an acceptable alternatives within a given set of constraints. This system reduces the time needed to reach a decision concerning the best routes to fly on a mission and even allows for practice flights of the route it has chosen. This provides a means of evaluating the results of the choice. Both of these are done in a fraction of the time necessary before it inception. This tool has helped the decision-maker (pilots) to choose among the alternatives available to them (flight plans) in an unstructured environment (conflict) and has done so in a timely fashion.

. The final stage of the OODA Loop is action. It is the carrying out of the decision. On the surface, it would appear that there is little that can be done to improve this phase; however, that is not the case. The gains to be realized are not found in the carrying out of the decision; that is beyond the scope of IRM. However, what can be addressed is how to

increase the pace at which the decision is conveyed to lower-echelon members for implementation.

<u>Proposition 7</u>. The speed at which decisions are acted upon can be increased by using enterprise-wide data models or interoperable computer systems.

Two IRM principles cited in the preceding chapters were brought together to form the basis of this proposition: 9: *Exploit information technology to benefit the organization* and 1: *Support decision-makers via readily available, accurate, and timely information.* The outcome was the idea that IRM should be able to improve the efficiency at which command and control takes place. In the past, communication was predominately done via radio or typewritten hard copy messages. This has begun to change. Increasingly, instructions from above, as well as that between horizontal units, is done on in an electronic format over the computer.

Once again, data models and open architecture standards come into play. In order to capitalize upon the electronic transmission such as email, FTP, and telnet, common standards must be in place such that the respective ISs can communicate. This is the most technical aspect of information resources management and concentrates on establishing and complying with standards of governing bodies such as the Institute of Electronic and Electrical Engineers (IEEE). These standards are the backbone of an interconnected information system; their use provides systems which can readily communicate with one another. This very fact can speed up the tempo of decision

implementation by removing the barriers which exist between non-interoperable ISs which currently exist. The following describes one illustration of Proposition 7.

The need for this ability (interoperability) is found in the development of a Global Command and Control System (GCCS). This was recently tested at the Joint Warrior Interoperability Demonstration 1995, where geographically dispersed military units from around the globe were linked together. Units from as far away as the aircraft carrier Kitty Hawk in the Pacific to Atlantic Command in Norfolk were able to simultaneously monitor information ranging from unit strength levels to the current state of logistics support.

> The objective of the demonstration was to show the capabilities of GCCS, proving it is able to handle the communications traffic needed to support U.S. forces anywhere, and to satisfy the communications needs of military operations simultaneously. At the heart of these new capabilities is GCCS, a powerful new tool for military planners that will be activated in December. With GCCS, military commanders can accomplish all the needed planning for conflict and execute that plan in a fraction of the time now required, said Air Force Col. David Fitzgerald, chief of staff of the Defense Information Systems Agency's Joint Interoperability Engineering Organization in Arlington, Va. GCCS is more than a communication system. It is a framework that determines what kinds of communication systems will be used to link all U.S. forces -- from the president to the soldier in the foxhole -- and is used to link new and existing military command, control, communication and computer systems.
>
> It also is a system to link and manage sensors that provide strategic and tactical information. Commanders will be able to use linked computer networks to conduct video teleconferences with squads involved in firefights, and those squads can communicate among themselves to show the location and disposition of the enemy. Commanders can monitor the progress of the battle, and call up reinforcing units as easily as clicking their computer mouse on an icon. Intelligence will be processed and disseminated instantly among U.S. troops, and will be sanitized automatically for dissemination among allies and government agencies, the agency officials said. (Cooper, 1995)

The Global Command and Control System is the newest innovation in command and control to be designed to integrate information systems. It speeds up the implementation (action) process by giving officers and their forces access to computers and interoperable communication systems. This augments their ability to control their forces because decision-makers can get and relay information to their troops in near real-time. This translates into being able to *act* upon their decisions at a much faster tempo than ever before possible.

Decision Quality and an Improved OODA Loop

The first section of this chapter examined how the OODA Loop could be shortened through the application of IRM principles to the various stages of the decision-making process. However, decision-making is about more than just coming to a quick conclusion. It is about coming to the *right* conclusion in the minimum time. If the only consideration were speed, then the OODA Loop could be shrunk to the point that it became no more than momentary in describing the length of time needed to reach a decision. No time would be needed to do more than a cursory attempt at any of the four stages. Such instantaneous decision-making would clearly put one within the decision loop of the adversary. Indeed, it would not be a significant logical leap to state that under such circumstances one could always function within the loop of a more deliberate opponent.

However, decisions reached and acted upon in such a manner will be flawed because they lack due consideration of both the environment and the outcomes they made bring about. Thus, it can be seen that at each stage of the loop a tension exists between time and decision quality. Boyd's model *presumes* that the decision-maker is pursuing quality and instead emphasizes time.

> Ironically, one of the greatest strengths of Boyd's theory is, at the same time, a potential weakness--the emphasis on the temporal dimension of conflict. Reflecting an American bias for fast-paced operations and the related preference for short wars, Boyd *presumes* that operating at a faster tempo than one's opponent matters; or, more to the point, it matter to the enemy. He may not care that we're "OODA Looping more quickly. Indeed, it may be in his interest to refuse to play by our rules. (Fadok,1995)

This weakness can be ameliorated. Boyd's model can be improved by including a quality aspect. This meets a middle ground by diluting the emphasis on time, increasing the importance of making a correct decision, and showing the impact the two have on one another.

<u>Time/Quality Tradeoff</u>. The tradeoff between time and decision quality is illustrated in Figure 16. The horizontal axis represents the amount of time consumed in processing through the decision-making process, while the vertical represents increasing levels of confidence in or quality of the ultimate decision.

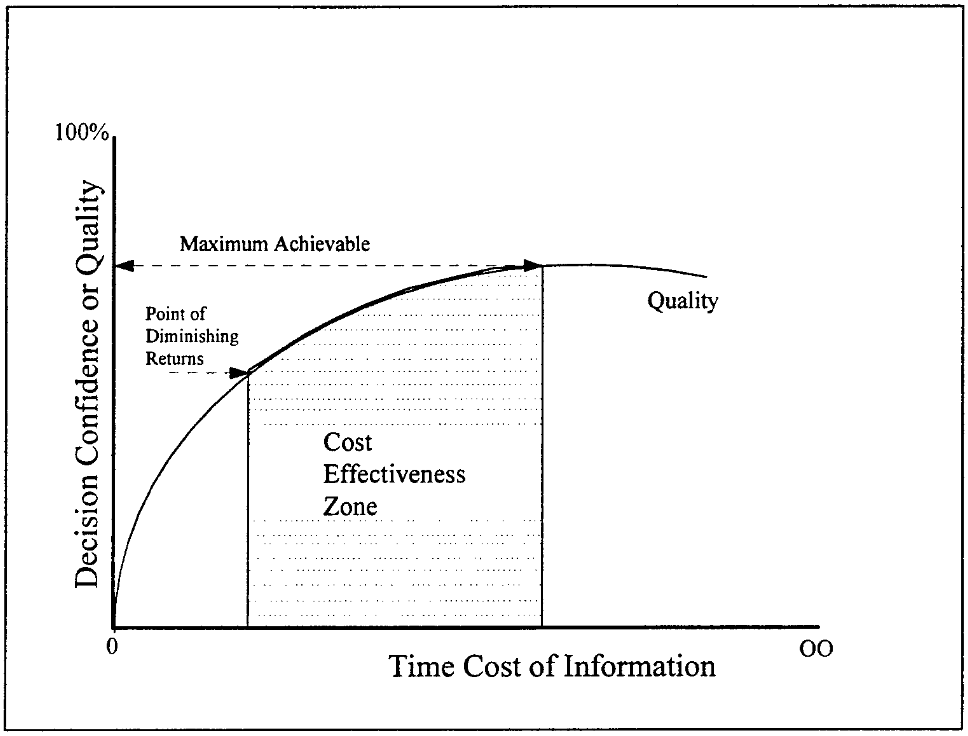


Figure 16. Time / Quality Exchanges

(Adapted From Harrison, 1987)

In the figure, increasing the amount of time used in collecting information results in a higher quality decision. However, while the degree of quality improvement afforded (per unit of time cost incurred) initially increases, it eventually reaches an inflection point after which its marginal value decreases. These decreases become more dramatic as more time is spent in reaching a decision until ultimately, more time spent reaching a decision actually has a negative affect. The problem remains to be an identification of where the two points (diminishing returns and maximum quality) lie.

> The key element is that there is a point at which the extra efforts to get additional information do not have a corresponding level of benefit. In other words, the effort outweighs the benefits. In attempting to identify, in theoretical terms, the point at which the effort to acquire information is paid off by the benefits of the information acquired, Harrison had to admit that the best achieved in the real world would be a zone of cost

> effectiveness. Such a zone not only accommodates the fact that identification of a balance point between effort and gain is not feasible in a real-world situation, but also that people will differ in what they will accept as good enough for the purposes. (Brown, 1993)

A decision of acceptable quality can then be defined as the point which lies in the zone of cost effectiveness. It should be noted that because of the ambiguities which occur in trying to identify these, it is unlikely that hard-and-fast algorithms could be used in deciding when one has gathered enough information. Instead, heuristics would likely be used, such that the decision-maker feels that he has within the zone of effectiveness. Further efforts may, or may not, bring about a better quality decision. However, the decision is made because the tradeoff between time and quality shifts to favor a quicker decision.

A New Look at Boyd's Loop. Figure 17 takes Col Boyd's OODA loop and adds the quality factor. Each phase of the decision-making process is viewed as a cyclical subprocess in its own right. The time required to complete the subprocesses is a factor of the rate at which it is pursued (tempo or speed) and the level of quality (confidence) needed before it can be deemed completed.

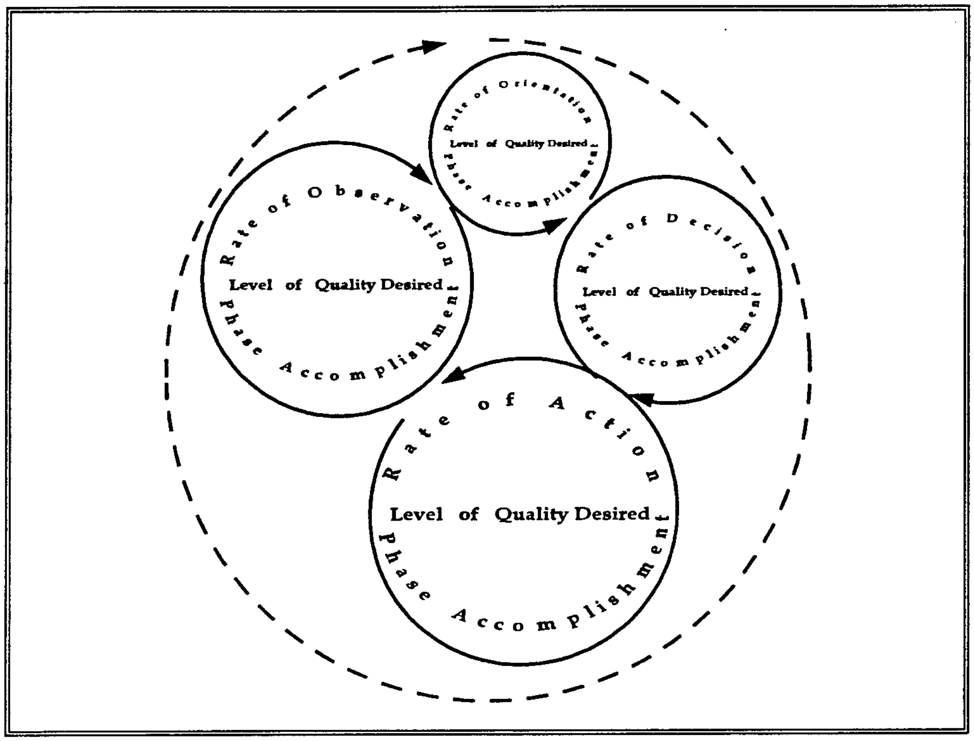


Figure 17. Augmented OODA Loop

The tempo of conflict will be dictated by the overall decision-making time required to navigate through the observation, orientation, decision and action sequence. It is possible, even probable, that two individuals presented with the same situation will react differently. In doing so, within the context of the augmented loop, their preferences for confidence/quality will dictate the size of their loops' subprocesses. Figures 18 and 19 illustrate two of the effects this can have on the overall decision-making process.

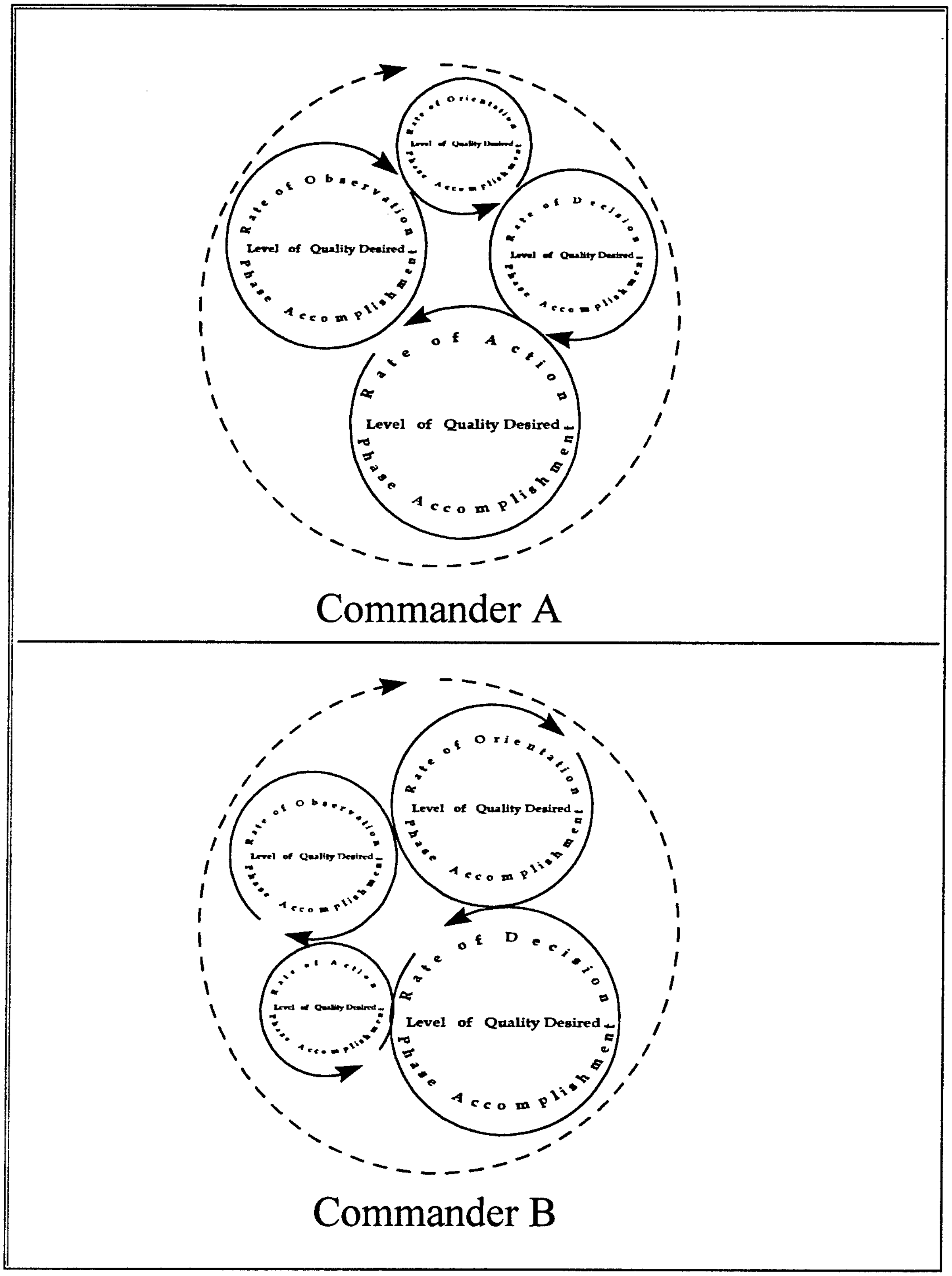


Figure 18. Comparable OODA Loops

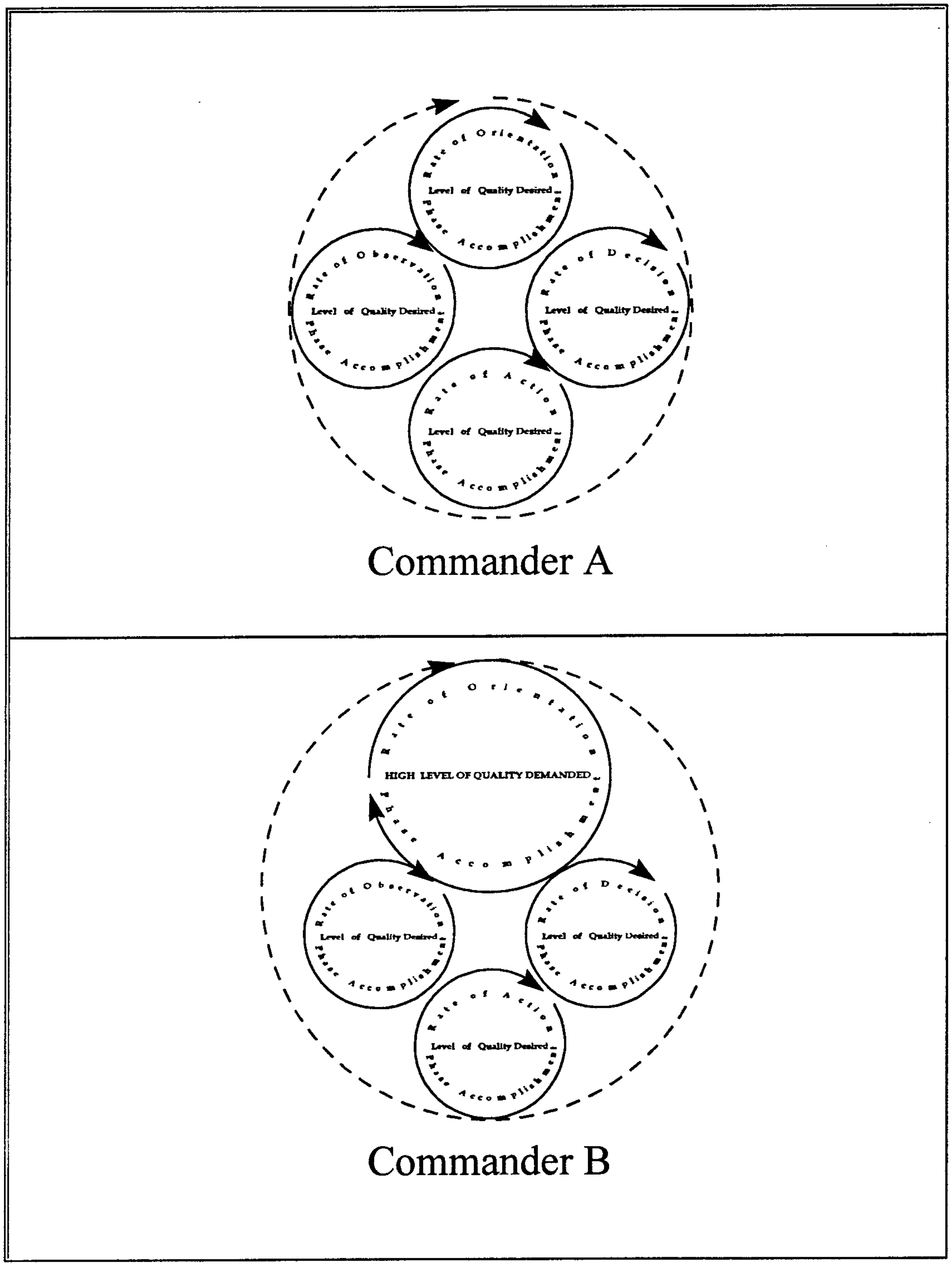


Figure 19. Disparate Orientation Phases

In the first illustration (figure 18), both sides in a conflict have different size subprocesses. They are accomplishing each phase at a different rate because they have different needs for quality. During the decision phase the commander B (on the bottom) takes significantly longer to decide which alternative to pursue. In this instance, it is because he desires more information before he is confident enough that he can make a wise decision. At his point, his opponent (Commander A on the top) has begun to move within B's OODA loop. However, at the next stage, Commander A's larger *Action* loop indicates he is slower, perhaps because of a centralized command structure which calls for significant communication and coordination of actions. The end result though, is that the disparity between the A and B's respective loops has disappeared. While there was significant differences in the rate at which the various subprocesses were accomplished, the time required to step through the entire process was comparable.

In figure 19, a different situation is faced. Here, two similar commanders are in conflict with each other. They observe, decide, and act at a nearly identical tempo. However, Commander B uses a significantly larger amount of time pursuing additional information with which to form his mental image and understand the environment. His observe cycle is vastly inflated. The effect of this is to allow Commander A to function within B's OODA Loop. According to Boyd, this will have a decisive impact on the outcome of the conflict to Commander B's detriment. His only hope for prevailing is that the time invested in pursuing quality will have enough of an impact on the overall outcome as to make up for the loss of time.

V. Conclusions and Recommendations

Introduction

This thesis investigated the evolving fields of information warfare and information resource management. It further examined the decision-making model of Col John Boyd, the OODA loop and offered it as a viable mechanism for understanding the impact of decision-making on conflict resolution. From these bases, a series of propositions were put forth on how to manipulate the OODA loop through applying IRM principles to its four stages. The lessons learned from this research are presented below.

Answers to Research Questions

Research Question 1.. What are information warfare and information resource management?

Due to the relative infancy of the information warfare field, there is considerably ability surrounding how to define IW. In reviewing the literature, alternative terms such as information-based war and knowledge-based war, cyberwar and netwar, and command and control warfare are often used interchangeably with information warfare. However, as a group, these all tend to share three common aspects. First, the idea that information is not the same as data. Information is data viewed in a context with meaning ascribed to it. Information systems, are the second aspect of IW. This is an expansion of IW to

include systems as "a comprehensive set of knowledge, beliefs, and the decision-making processes and systems of the adversary" (Szafranski, 1995). The third aspect of information warfare is the decision-maker. Since this is the adversary's control point, it is here that the potential for leverage is greatest. These three attributes: information, information systems, and decision-makers are the basic IW components. Most IW definitions build on them.

IW as identified in this research is oriented around battle and conflict. Two of the better interpretations from this orientation are that of the Department of Defense and the Air Force.

> Actions taken to achieve information superiority in support of national military strategy by affecting adversary information and information systems while leveraging and defending our information and systems. (DoD)

> Any action to deny, exploit, corrupt, or destroy the enemy's information and its function; protection ourselves against those action; and exploit our own information functions. (DAF, 1995a)

These capture the need attain information dominance. In doing so, they widen the scope of an IW definition. For the purposes of this research, the Air Force's view of IW is warfare is preferable because it is not constrained to information and information systems. As such, IW should be considered as *those activities which are taken to deny, exploit, corrupt or destroy and enemy's information or information functions and protecting ourselves against those actions*. Under such a broad tasking, the term information functions describes a whole gamut of operations. IW, as a concept, must capture that in order to be prevent it from becoming too parochial.

Information resource management is the treatment of information as an organizational asset on par with personnel, capital, and land. The concept of IRM has been in existence since the late 1970s and has come to mean stewarding information through effective and efficient management of information resources. Although no universally accepted definition currently exists, IRM's fundamental premise is that information and its associated technologies are vital to the organization and as such require the same skillful management applied to other factors of production .

The import of this view is that it recognizes both the value inherent in organizational information, and the need for cultivation to maximize its utility. IRM is then, in its simplest sense, a the set of concepts to be used in the management of information as a organizational resource. In another view, IRM strategies are tools to mesh information technological capabilities with user information requirements. In this conception, IRM is a mechanism through IT is liked to organizational processes and user needs.

A review of the literature reveals that there is a lack of consensus as to what constitutes information resource management. One set of researchers who understood a study to clarify the IRM construct were Lewis et al. They identified 44 separate activities that IS professionals attributed to IRM from which they expounded on 8 general dimensions of this field: *Chief Information Officer*; *Planning; Security*; *Technology Integration; Advisory Committee; Enterprise Model; Information Integration*; and *Data Administration*. Their definition served as the foundation for understanding the basic principles of IRM as used in this research.

> IRM is a comprehensive approach to planning , organizing, budgeting, directing, monitoring and controlling the people, funding, technologies and activities associated with acquiring, storing, processing and distributing data to meet a business need for the benefit of the entire enterprise. (Lewis et al, 1995:204)

With this definition, IRM is then: *Those activities incorporating the following principles*:

1. Support decision-makers via readily available, accurate, and timely information
2. Acquire and manage information resources in an economic and effective manner
3. Cultivate horizontal as well as vertical information sharing
4. Link strategic information planning to support of organizational objectives
5. Implement information planning at all management levels
6. Provide cradle-to-grave information management
7. Involve end-users in all stages of the information life-cycle
8. Emphasize information stewardship not information ownership
9. Exploit information technology to benefit the organization

Research Question 2.. What is the role of decision-making in information warfare?

Based on this research, it appears some aspects are common to most information warfare definitions: information, information systems, and decision-makers. Yet, few focus purely on affecting the decision-making process. Taking a holistic approach where all three components are balanced would minimize the emphasis on what should or

should not be included as part of information warfare. This is the IW niche decision-making fills. Decision-making's role in information warfare is, then, to serve as a nucleus around which all other efforts are structured.

The value inherent in any information-related tactic is its enhancement of decision-making. Thus, the manipulation of the decision-making process serves as the core of a balanced IW approach. Colonel John R. Boyd's Asymmetric Fast Transient theory of conflict captures this idea. The model's fundamental premise is that decision-making is the result of rational behavior which flows through four stages: observation, orientation, decision, and action (OODA). According to Boyd, the goal of conflict in is to navigate through the OODA loop more rapidly than one's adversary. In conflict, both sides are attempting to accomplish this task simultaneously. with the successful one able to seize the initiative and thereby force its opponent into a defensive stance. Boyd's contention is that the decision-makers' cognitive processes are the key to prevailing in a conflict. Information warfare then, must be predominantly concerned with denying the enemy the time needed to adjust/adapt to wartime situations. Decision-making, in an information warfare context, serves as a focal point for all the IW mission

Research Question 3. How can the application of IRM principles leverage IW by shortening the amount of time needed for decision-making?

Chapter four presented an in-depth analysis of the data found during research. Application of IRM principles were proposed to improve IW (by shortening the decision-making process) in the following seven ways.

- **Proposition 1: The time required to accumulate sufficient observations can be shortened by maximizing the amount of pertinent data initially entering the IS**

- **Proposition 2: The time required to accumulate sufficient observations can be shortened by changing the organizational structure concerning information from emphasizing information ownership to information stewardship.**

- **Proposition 3: The time required to accumulate sufficient observations can be shortened by structuring organizational data such that it can be more readily accessed by multiple systems.**

- **Proposition 4: The time required to orient can be shortened by minimizing the time decision-makers must spend analyzing information presented by the IS.**

- **Proposition 5: When the inputs of multiple personnel are required to reach a decision, fostering horizontal information sharing can shorten orientation time**

- **Proposition 6: The time required to choose among competing alternatives in an unstructured problem can be shortened by implementing IT tools which are tailored to the decision-maker.**

- **Proposition 7: The speed at which decisions are acted upon can be increased through the use enterprise-wide data models and interoperable computer systems.**

Research Question 4.. Is there a tradeoff between the quality of a decision quality and the speed at which it is reached and if so, how is this reflected in IW?

This question is addressed to the valid concern that enhanced decision-making is about more than just coming to a quick conclusion. It is about arriving at the correct conclusion in as short a period of time as possible. Decisions based solely upon a speed orientation can, at the extreme, become flawed due to an inadequate understanding of the environment and consequences. Thus, it can be seen that at each stage of the loop a tension exists between time and decision quality.

This tension is exasperated because the amount of time necessary to reach a quality decision quality is not static. The degree of quality improvement afforded (per unit of time cost incurred) initially rises, but eventually reaches an point beyond which its marginal value declines. These decreases become increasingly dramatic as more time is spent in reaching a decision until, ultimately, spending more time reaching a decision actually has a negative affect. This is important to recognize because their is a point beyond which extra efforts to secure additional decision quality do not reap corresponding benefits

The time/quality tension has a significant impact on the application of IRM to the OODA loop stages. At the core of Boyd's model, IRM needs to be concerned with improving the tempo at which the stages can be accomplished. However, when considering the various ways in which this can be accomplished, consideration *must* be given to the quality of the decision reached because it is the time investment in searching for quality/confidence that determines the size of the OODA loop's stages. IRM professionals need to look for balance between the two concepts. Not enough concern for quality and conflicts are lost because the adversary out maneuvered you. Too much time taken to get a higher degree of decision quality and one risks the encountering the adage, *paralysis-by-analysis*.

Limitations

This research was limited to the development of an expanded model of rational decision making, and the presentation of propositions that flow from this model.

Furthermore, empirical research will be necessary to ascertain the usefulness of this model and its resulting propositions.

Conclusions

In the era of drawdowns and shrinking budgets, military leaders are seeking to use information as a tool to leverage their forces. Information warfare is this field of study, but there is little agreement as to what IW entails. This notwithstanding, maximum gains stand to be realized by preventing it from becoming too parochial. This research indicated that IW should encompass those activities which focus on information *functions* because , in doing so, significantly more of the broad information-mission taskings are captured. Furthermore, the thesis explored a major warfare decision-making model (the OODA Loop) and developed an improved model through inclusion of IRM principles. Propositions were drawn from this new model and their implications were discussed.

Recommendations for Further Research

This research constitutes only a preliminary foray into the exploration of the role of information resource management in the IW realm. Additional work needs to be done on the viability of creating an information doctrine which focuses upon the question of achieving information superiority through the implementation of IRM principles. Research also should be done on the feasibility of identifying pertinent information within the external environment before conflicts begin. Finally, the model developed and

the resulting propositions provide a basis for further research that can seek to confirm, modify or disprove the value of this approach.

Appendix A: Glossary of Acronyms

ADP .... Automatic Data Processing

AFIT .... Air Force Institute of Technology

ARCNET .... Army Central Command

BDA .... Battle Damage Assessment

DA .... Data Administrator

DAF .... Department of the Air Force

DoD .... Department of Defense

DoDD .... Department of Defense Directive

C4I .... Command, Control, Communications, Computers, and Intelligence

CIC .... Combat Information Center

CINC .... Commander in Chief

CIO .... Chief Information Officer

DSS .... Decision Support System

EIS .... Executive Information System

FTP .... File Transfer Protocol

GCCS .... Global Command and Control System

GLO .... Ground Liaison Officer

GTN .... Global Transportation Network

IRM .... Information Resource Management

IS .... Information System

IT .... Information Technology

ITV .... In Transit Visibility

JFACC .... Joint Force Air Component Commander

IW .... Information Warfare

MARCNET .... Marine Corps Central Command

OMB .... Office of Management and Budget

OODA .... Observe, Orient, Decide, Act

USAF .... United States Air Force

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Vita

Captain Gregory M. Schechtman was born on 13 January 1963 in San Jose, California. He grew up in New Hampshire. He returned to San Jose in 1979 where he graduated from Westmont High School two years later. In 1985, he enlisted in the USAF and worked for three years as an F-15 tactical aircraft maintenance specialist. He left the Air Force to pursue a degree in finance from The Florida State University. Upon graduation in 1990, he was granted his commission through the ROTC program. His initial duty assignment was to Malmstrom AFB, Montana, where he was assigned to the 12th Strategic Missile Squadron. There he served as a Minute Man III Missile Combat Crew Flight Commander and Instructor. In 1994, it was his distinct privilege to represent his squadron at Guardian Challenge, Space Command's inaugural space and missile competition. While serving at Malmstrom he completed a Master's in Management Information Systems through the University of Montana. In 1995, he cross trained into the communications and computers career field and entered the School of Logistics and Acquisition Management at The Air Force Institute of Technology. He completed his Master of Science in Information Resources Management in 1996. His follow-on assignment is to Langley AFB, VA.

He is proud to be married to the former Susan Jossi, of San Jose, California and has three beautiful children: Benjamin, Brandi, and Andrew.

Permanent Address: 1576 Fruitdale Ave.

San Jose, Ca 95128

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1996	Master's Thesis

4. TITLE AND SUBTITLE
MANIPULATING THE OODA LOOP: THE OVERLOOKED ROLE OF INFORMATION RESOURCE MANAGEMENT IN INFORMATION WARFARE

5. FUNDING NUMBERS

6. AUTHOR(S)
Gregory M. Schechtman, Captain, USAF

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)
Air Force Institute of Technology
2750 P Street
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GIR/LAL/96D-10

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Bao T. Nguyen, SAF/AQIO
1060 Air Force Pentagon
Washington, DC 20330-1060

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 Words*)
A ground-swell of interest in information as a weapon of warfare is growing within the U.S. armed services. Military strategists are looking at information as a tool to leverage our forces and make them irresistible in battle. Yet, there is little agreement as to what information warfare (IW) is, let alone how it is best fought. This fundamental disagreement is serving as an impediment to unified actions as the Air Force seeks its role in this arena. In particular, information resource management practitioners are questioning their role in supporting this mission. This thesis discusses limitations of existing information warfare interpretations in light of Col John R. Boyd's decision model, the Observation-Orientation-Decision-Action (OODA) Loop, and offers a synthesized model of information warfare for use in the Air Force. It then offers information resource management (IRM) as a viable decision-support mechanism in that interpretation. By analyzing the applicability of information resource management to the Air Force IW mission, this thesis proposes a better way to view information: a tool for winning the information war through making superior decisions more rapidly than our opponents. An understanding of how IRM and IW relate to one another will provide a model for achieving and maintaining dominance of this new realm of warfare.

14. SUBJECT TERMS
IRM, IW Information Warfare, Decision Making, Information Systems, Management Information Systems, OODA Loop, Boyd, Information Theory

15. NUMBER OF PAGES 128

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

AFIT Control Number AFIT/GIR/LAL/96D-10

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